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Entropy, Gravitation, and Thermodynamics

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Abstract: The intrinsic motion of light produces expanding and cooling space; the intrinsic motion of matter (gravitation) produces increasing ages of time. These two intrinsic motions are expressions of entropy in free and bound energy, respectively. Hence the dimensional conservation domains of light and matter are the products of entropy, connecting the first and second laws of thermodynamics. Gravity creates time from space, forming an energetically necessary linkage and equilibration between the conservation domains of light and matter. Gravity is the conserved intrinsic motion of light; gravity's product, time, is the conserved entropy of light. Gravitational energy is derived from the intrinsic motion of light; the deceleration of the Universe provides the energy for the creation of time. The place of gravitation in the triangular connection between the 1st and 2nd thermodynamic laws and symmetry conservation (Noether's Theorem) is examined in terms of a "location" charge whose active principle is time.

Keywords: symmetry, information, Noether, Bekenstein, black hole, entropy, gravity

Introduction

In this paper I will examine the role of gravitation in the context of 3 physical principles: energy conservation, entropy, and the conservation of energetic symmetry (including charge conservation).

The first law of thermodynamics concerns the conservation of energy: in any isolated system, the total energy remains the same. The second law of thermodynamics concerns entropy: in any isolated system, the capacity for work by that system must decrease over time.

Three conditions characterize the change of entropy within a system [1]:

1) the change in entropy depends only upon the difference between the initial and final states of the system;
2) in reversible systems the entropy change is zero;
3) in irreversible systems the entropy change is positive.

In addition to the first and second laws we encounter another principle, the conservation of energetic symmetry, which is not a thermodynamic law, but is nevertheless related to both the first and second laws in significant ways. This principle, which is strictly conserved, was mathematically formulated by Emmy Noether and is known as "Noether's Theorem". It states that in a multicomponent field, such as the electromagnetic field, whenever one finds a symmetry one will find an associated conservation law, and vice versa: conservation laws have associated symmetries. Hence symmetry's relationship to the first law. I like to think of Noether's theorem as the "truth and beauty theorem", for it is essentially a mathematical translation of Keats' poetic intuition that "Beauty is truth, truth beauty...", where truth is

conservation and beauty is symmetry [2].

Symmetry conservation is also related to the second law because symmetric systems generally have greater (positive) entropy than asymmetric systems; hence symmetry conservation drives toward higher entropy states. This is especially evident in the tendency of all forces to convert bound energy to free energy, as light has both the greatest symmetry and the greatest positive entropy of any energy form. Symmetry conservation is most familiar to us in the guise of charge conservation, since the conserved charges of matter are all symmetry debts of light, incurred during the conversion of symmetric light to asymmetric matter during the Creation Event ("Big Bang"). (See: "Symmetry Principles of the Unified Field Theory".) Entropy and symmetry are also physically connected by both light and gravitation. The electromagnetic constant and the velocity of light, c, is both the gauge magnitude of light's symmetry and light's entropy, as light's intrinsic motion is an expression of both. In turn, gravitation is both the conserved intrinsic motion of light and the symmetry debt of light's non-locality. Gravity is the force which converts the positive entropy of light and expanding space into the negative entropy of time and ageing matter.

Entropy

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

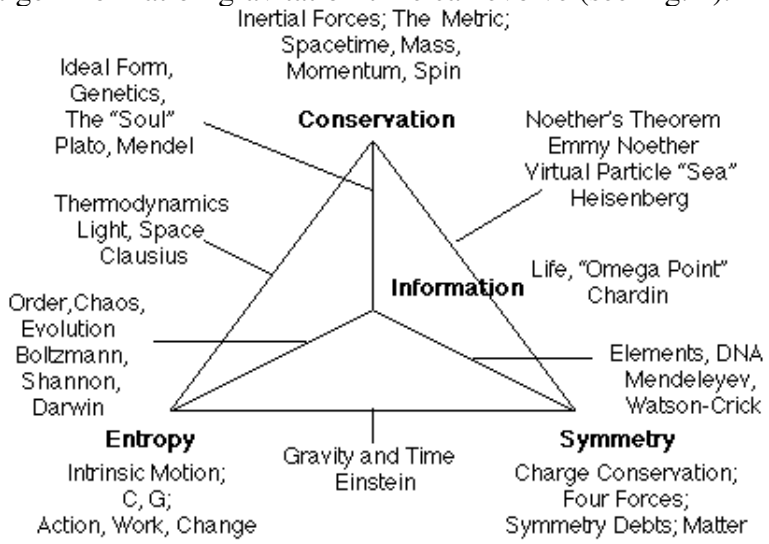
The expansion is not driven by energy conservation, for at any given moment the total energy of this Universe remains the same as it was at the beginning, the constant product of a declining temperature but increasing volume. That is, the "light Universe" does not need to expand in order to conserve energy; energy conservation regulates the expansion but does not demand it. Similarly, the expansion of the light Universe in not driven by the conservation of energetic symmetry - "hot" light is just as symmetric as "cool" light, so as in the case of the first law, symmetry conservation is a regulator, not a driver, of this process. Energy conservation will regulate the constant product of temperature and volume by linking the metric and energetic parameters of energy through the electromagnetic constant c; symmetry conservation will prevent the conversion of light to matter.

However, the second law demands the spatial expansion and is therefore the thermodynamic driver of the process, since the second law requires that the capacity of this isolated system for work must decline over time, requiring the light Universe to cool, which it can only do by expanding. Therefore, we see that the second law (entropy) is the thermodynamic reason why the light Universe must expand, and why light must have an intrinsic spatial motion.

We can also see that the second law requires a dimensional system (spacetime) in which to operate. The whole meaning of the second law requires a one-way dimensional driver, time, since the second law requires the capacity for work by any system to decrease over time. This cannot happen in the light Universe unless the system can cool, which requires expansion in physical space. Hence we can attribute the dimensional parameters of our cosmic system to the second law - the first law requires only that energy and its dimensional expression (if it has one) be linked in such a way that conservation is achieved - as the constant product of temperature and volume at any given time, for example.

The function of the second law is therefore to permit change. Without the second law the Universe could not spend its energy capital - it could not act or evolve; it would be static rather than dynamic. Together, the first and second laws allow change within a dimensional system which conserves energy. Symmetry

conservation allows this system of conserved changes to take a further evolutionary step - the conversion of light to matter - through the addition of a system of conserved charges, the symmetry debts of light. It is symmetry conservation that translates energy into information. Finally, entropy conservation converts space to time via the gravitational force. With these several conservation measures in place, if the initial symmetric energy state of the Cosmos can be broken, the negentropic Universe of mass-charge-information-gravitation-time can evolve (see Fig. 1).



The Energy Tetrahedron

(connections between the physical poles)
(see also tetra2.gif, tetra3.gif, tetra4.gif and tetrabt.html)

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Conceptual geometry: relationship among the principles ordering the expression of electromagnetic energy in our Universe

Figure 1.

Energy Conservation

The electromagnetic constant c is the "gauge" of the metric of spacetime, the fixed relationship between the dimensions. We take for granted the fact that meter sticks do not vary in length, nor clocks vary in rate, regardless of their orientation or location in space or time. Clocks and meter sticks in Hong Kong run at the same rate and have the same length as clocks and meter sticks in New York, and could be freely exchanged without any measurable difference. Furthermore, the relationship between the length of a meter stick and the rate at which a clock runs is similarly invariant. This fixed, simple dimensional relationship is absolutely necessary for the conservation of energy; without it, velocity, momentum, and energy of all descriptions would vary chaotically from place to place, time to time, and according to orientation. Hence the stable metric displays a symmetry (a sameness) with respect to location and orientation in space or time, and this symmetry is a manifestation of energy conservation, perhaps our most fundamental example of Noether's theorem and the connection between symmetry and conservation. We become aware of the breaking or distortion of this metrical symmetry in the presence of gravitational fields or the inertial forces due to accelerations - but these are both phenomena associated with time and the asymmetric realm of matter.

In the light Universe, time, gravitation, and the inertial forces which attend matter do not exist. What inertial force does exist can be said to maintain the constancy of c and the symmetry of the purely spatial metric. Without the metric, there would be no structure to regulate the expansion of the Universe such that its temperature and volume would yield a constant product over time, in satisfaction of the first law. In natural units, c regulates ("gauges") the metric such that one second of temporal duration is metrically equivalent to 186,000 miles of linear space. In other words, the velocity of light is a natural expression of the metric, the symmetric relationship between the three spatial dimensions, and between space and time. The magnitude of c cannot vary or the first law cannot produce the constant product of volume and temperature in the expanding Universe.

Einstein discovered that light has no time dimension, that at velocity c the "clock stops" and space shrinks to nothing in the direction of motion. Light is a 2-dimensional transverse electromagnetic wave whose intrinsic motion sweeps out a third spatial dimension. The light Universe does not contain an explicit time dimension, it is purely spatial, which makes sense in that being one-way, time is an asymmetric dimension which would destroy the metric symmetry of light-space. The essential meaning of c is that it is the conservation-symmetry gauge of the spatial metric, which functions specifically to prevent the formation of the asymmetric, one-way time dimension. The dimensional and energetic parameters of this system are thoroughly linked such that the wavelength of light (its spatial expression) multiplied by the frequency of light (its temporal expression) always equals the constant c.

Obviously, time is implicit in the frequency of light, but at c time is prevented from becoming explicit. The seed is present, but its growth is suppressed; indeed, time would be required in its explicit aspect should light assume its particle form and produce matter. In fact, we need to discover the origins of the time dimension in light if we are to build a truly unified theory of energy and its dimensional conservation domains, a theory which traces the origin of all forces to light.

In the case of matter, time is explicitly required by energy conservation to keep the energy accounts of massive particles (for example, the conservation of momentum, in which the variable energy content of matter depends upon its variable velocity, where velocity = distance divided by time). Light does not explicitly require time for the same reason, since light's velocity never varies: the energy content of light varies instead with its frequency.

It is the ever-present threat of time, implicit in the very nature of light (frequency), which propels the electromagnetic wave forward in space to protect its metrical symmetry. The flight of space from time produces the intrinsic motion of light, a symmetric dimensional state of energy fleeing an asymmetric dimensional expression which is an internal potential of its own nature. Since this flight also produces the (positive) march of entropy, we see again that energy conservation, symmetry, and entropy are all related and share a common factor, c.

Systems come into being through the intersection of a symmetric conservation domain with an asymmetric conservation domain. The metrical gauge c is a symmetry condition preventing the intersection of space and time, and thus preventing light from manifesting as matter.

Symmetry and the "Interval"

The "Interval" is Einstein's mathematical formulation of an invariant quantity of spacetime separating two events. Due to their relative motion, and the finite speed of light, some observers of these events will see more space, while others will see more time, and they will generally not be able to agree on

precisely when the events occured; nevertheless, if all their observations are entered into Einstein's mathematical formula, they will all find the same "Interval" [3].

Einstein realized that the Interval of light is zero - which is his essential mathematical formulation of the metrical symmetry condition of light and the fundamental role of c as a symmetry "gauge", or regulator. The zero Interval means that light is "non-local" - its position in spacetime cannot be specified - hence light must be considered to be everywhere within its conservation domain simultaneously. The reason the Interval of light is zero is that light lacks both a time dimension and one spatial dimension (in the direction of its forward motion). You cannot specify a location in 4-dimensional space if you lack even one of the 4 necessary coordinates, much less two.

Of various symmetries associated with light's zero Interval, two are of special importance for our discussion of gravitation. The first is light's lack of an asymmetric time dimension, resulting in the metrical symmetry of space - there are no energetically preferred spatial dimensions in light-space (compare with the energetically favored direction "down" in the gravitational space of matter. Light does not produce a gravitational field - the field could not center itself upon any fixed position or specifiable location). Secondly, because light is everywhere within its spatial domain simultaneously, light's energy is distributed symmetrically throughout its conservation domain (compare the lack of distributional symmetry in space of the concentrated and immobile energy state of matter).

When light is converted to matter, these metrical and distributional symmetries (among others) are broken. The broken symmetries of light are conserved, however, as the various charges of matter. The principle of symmetry conservation is therefore most familiar to us as the principle of charge conservation. It is the broken metrical and distributional symmetries of light that give rise to the "location" charge of gravitation, a charge whose active principle is time. The function of all conserved charges is to produce forces which will eventually return the system to its original symmetric state. Our Sun is the archetypical example of this on-going process - stars use the natural forces generated by the charges of matter to convert mass to light.

The role of symmetry conservation is two-fold: 1) to prevent the devolution of the symmetric light Universe into a Universe containing asymmetric matter, time, and gravitation, that is, to prevent the conversion of light to matter and space to time with its attendant gravitational field (this preventive function is manifest through the role of electric charge in the annihilation reations of matter-antimatter particle pairs); and 2) to conserve (should its preventive efforts fail), the symmetry debts of light and space as the charges of matter, so this information may be used, through the forces generated by those charges, to return matter to its original symmetric state, light. (It is thought that the symmetric state of our electromagnetic system was broken by asymmetries inherent in the weak force during the initial moments of the Creation Event) [4]. Finally, since light has the greatest entropy of any energy form, energetic symmetry conservation also furthers the (positive) entropy drive.

The central problem to be solved by the manifest Universe is how to return to its original symmetric state given the absence of antimatter. The information contained in the charges of matter (the symmetry debts of light) is sufficient for the task, but requires an additional dimension, time, in which to act. The slow return to its symmetric state of the great energy stored in matter provides both the time and free energy for biological systems such as ourselves to evolve and meditate upon our origins.

Matter

Now imagine the beginning of a Universe such as our own, composed of light and matter. In the beginning, the Universe has its greatest capacity for work, since its energy is the most concentrated. The "work done" at the beginning of our Universe is the creation of matter; never again will the Universe be hot enough to repeat this act (unless it collapses in a "Big Crunch"). The creation of matter provides the storehouse of energy whose slow release fuels the evolution of the material Universe. How does the creation of matter affect the cosmic march of entropy as manifested through the intrinsic motion of light and the expansion of the Cosmos?

Matter is created by the conversion of light to massive particles via the (asymmetric) interaction of the strong and weak force (See: "The Formation of Matter and the Origin of Information"). But matter has no intrinsic spatial motion, and therefore cannot participate in the expansion of the Universe and the spatial march of entropy, as does light.

The conversion of light to matter breaks the symmetric state of the light Universe both dimensionally and energetically. Dimensionally, matter is no longer integrated with space, as it has no intrinsic spatial motion. Instead, matter acquires a metrically equivalent intrinsic motion in time, as is required by the conservation of energy to balance matter's energy accounts. Note that both light and matter have intrinsic motion in their respective conservation domains, space and time, and that one intrinsic motion is metrically equivalent to the other. Matter moves as fast in time as light moves in space, in terms of their metric equivalents. This equivalence is required by the first law to allow matter and light to exist together within a compound but unified dimensional domain (spacetime) which can simultaneously accommodate their disparate energy conservation needs. This equilibrating connection between space and time is produced by the gravitational force, gauged by the universal constant, G. Hence it is G which determines the universal clock rate for matter and connects matter to the spatial metric, gauged by c. Gravity is a dimensionally active force, representing a couple between matter, space, and time. This is the basis of the observation that gravity "slows clocks and shrinks meter sticks".

In terms of energy, matter is more than an inert lump of concentrated, asymmetric light energy. Matter is created not only with a time dimension but with other charges as well (all of which can be characterized as various symmetry debts of light), the charge of interest here being time and the "location" charge, the source of the gravitational field.

Gravitation is the most universal charge of matter, carried by any bound form of energy, that is, any form of energy which lacks intrinsic motion c and has intrinsic motion in time (all energy forms have either intrinsic motion c or intrinsic motion T; if they have intrinsic motion T, then they also have intrinsic motion G (gravitation)). Time and gravitation are the universal companions of matter, and it is more than coincidence that these three are always found together - indeed, they are bound in a causal triangle.

Let us return to the birth of our Universe and imagine again the initial expansion, beginning with pure light. The expansion is faithfully obeying energy conservation and the march of (positive) entropy when suddenly some of its light is converted to matter. The conversion of light to matter poses a number of interrelated conservation problems for the Cosmos. I will try to separate them as best I can in what follows.

First, there is the problem of raw energy conservation. This is partially resolved by storing the raw energy of light in the form of the mass and momentum of particles. However, unlike light, a massive particle requires an explicit time dimension to keep its total energy accounts - the problem of momentum

mentioned above. Since no explicit time dimension exists in the light Universe, one will have to be created. However, the creation of a time dimension will require an energy (entropy) source - just as space requires the entropy-energy (intrinsic motion) of light for its creation. Dimensional conservation domains are the creation of entropy, whether positive or negative, space or time. We will return to this point.

Second, there is the problem of symmetry conservation. The symmetry of light must be conserved no less than its raw energy (Noether's Theorem). This problem is redressed through the creation of the conserved charges of matter, all of which represent symmetry debts of light. One of these is the "location" charge involving time and the non-locality of light which is partially the cause of the gravitational force.

Third, there is the entropy problem referred to above. In the light Universe entropy had a spatial expression (the expansion and cooling of space), produced by the intrinsic spatial motion of light. Matter has no intrinsic spatial motion, hence its energy has no spatial expression of entropy. Since entropy concerns itself with change, we need to associate some active energy principle with matter, one that can cause change, action, and evolution, if the entropic drive of light is to be somehow conserved in matter.

The solution adopted by nature, which satisfies the requirements of both the first and second laws at a single stroke, is to create time from space by means of the gravitational force. This "internal" solution automatically addresses the problem of how to transfer light's entropic flow to matter's entropic flow, where the energy to create the time dimension will come from, and how to equilibrate and connect the metric of the spatial and temporal conservation domains.

The entropic spatial flow of light, light's intrinsic spatial motion, is transferred to matter as the flow of space toward matter - the gravitational field itself is matter's active expression of entropy. This transfer is produced by a change in time from an implicit condition in light to an explicit condition in matter. This simple switch from implicit to explicit in the condition of time is the whole difference between light's intrinsic spatial motion and matter's intrinsic spatial motion, the flow of space to matter which we recognize as matter's gravitational field.

We can think of matter as storing light's entropic march in its gravitational field, just as it stores light's energy in mass. Similarly, matter stores light's symmetry as conserved charges, and converts light's spatial conservation domain to time (via gravity). All these conversions are reversed when symmetry conservation returns the system of matter to light.

The symmetry losses of light are carried as the conserved charges of matter, which produce forces returning the system to symmetry. The conversion of mass to light by our Sun is an example already cited, but others involving the complete conversion of matter to radiation are known, including matter-antimatter annihilations, proton decay, and Hawking's quantum radiance of black holes [5].

The active, forceful component of time is gravitation, just as the active, forceful component of space is the intrinsic motion of light. These forceful components produce the entropic drives of their respective dimensional domains. But since time is produced from space by gravitational conversion, we see that time is derivative, space is primary, and the gravitational "couple" to space is essentially parasitic, siphoning off the expansive energy component of space to create time. Time is produced at the expense of space; gravity "eats" space, producing a time residue, and the energy of gravitation is just the expansive or entropic light energy resident in the space that it consumes - the energy which produces the

intrinsic motion of light. (This is not the energy of the photon itself. Photons of all energies have the same intrinsic motion. In the conversion of light to matter, the great bulk of the photon's energy is stored as the mass (and momentum) of the particle. It is only the energy which produces the intrinsic motion of the photon that we are speaking of here as the source of gravitational energy. Gravity is weak because it takes very little energy to give a photon its intrinsic motion; gravitational energy is entropy-energy).

With matter present, the entropic march of light continues through the expansion of the Universe, but at a slower rate. Gravitation compensates this loss exactly in matter's entropic spatial march. The deceleration of the universal expansion supplies the energy to create the time dimension. If enough matter is present, gravity "eats up" space faster than light creates it, the Universe collapses in a reversible process, and the entropy tally sums to zero. (Gravitational entropy is tallied as "negative" entropy, light entropy is scored as "positive", since the two act directly oppositely each other. The implicit-explicit time "switch" is therefore also a positive-negative entropy "switch".) Because light does not produce a gravitational field, the conversion of mass to light by stars will slowly reduce the total gravitational force present in the Universe. Since no new matter is created to compensate this effect, the universal expansion rate will appear to (slightly) increase over time.

The gravitational force we feel at the Earth's surface is the flow of space creating Earth's time dimension. It is the equivalent of the energy of intrinsic motion of the light which created Earth's mass. It is the spatial expression of Earth's entropic march that we feel as gravity's relentless pull. It is the force necessary to unify Earth's temporal domain with light's spatial domain, essentially Earth's connection to the spatial Universe. The spatial flow is never-ending because of Earth's intrinsic motion in time; the time dimension moves and hence must continuously be renewed. The only way to get rid of gravity is to get rid of the time dimension which energy conservation requires for matter. This can only be done by converting matter to light, which has neither a time dimension nor the gravitational field to produce one.

The Mechanism of Gravitation

Matter is produced from light by the collapse of light's "wave function" to a concentrated form, probably involving a multi-dimensional "knot", in which the spatial metric and the electromagnetic wave become entangled in a specific way (via the "Higgs" particle and the Intermediate Vector Bosons of the weak force). The resulting "knot" or particle is a new, combined energy form of higher dimensionality which space cannot transmit as a simple vibration of its structure. Light is a 2-dimensional transverse wave, and apparently space can only transmit 2-dimensional energy forms. Hence the higher dimensional "knot" combining energy with the spacetime metric can no longer be transmitted, resulting in the intrinsic spatial "rest" of matter. "String" theory is currently investigating the geometric nature of these multi-dimensional "energy" knots which evidently comprise matter [6].

When an electromagnetic wave collapses or becomes "knotted", it brings with it the spatial volume or metrical component of space which the light occupied - light and its conservation domain cannot be separated. But Einstein has taught us that space can be converted to time, so it is fair to assume that this collapse of space must produce a time residue, in effect, a time "charge" in an amount corresponding to the metric equivalent of the space collapsed. It is fair to call this time residue a charge because time is asymmetric; being one-way, time has the asymmetric or informational character of any other isolated charge of matter. The asymmetric time charge produces a specific "location" in the otherwise symmetric field of space - giving the massive particle it is associated with a positive Interval, whereas the light from which it was produced had a zero Interval. The symmetric field of space surrounding this time or

"location" charge of matter responds by trying to neutralize the asymmetry in the metric field represented by the explicit appearance of time. Space moves toward the time charge, in a vain attempt to neutralize it by converting time back to symmetric space. But time is asymmetric, and while space can be converted to time, time cannot be converted to space. This is essentially because time is the energy conservation domain of matter, which is necessarily transient and one-way in its function - a two-way time dimension would violate causality and energy conservation (both first and second laws). (Converting time to space would amount to producing antigravity. The closest we come is in the conversion of mass to light.)

As the spatial metric moves toward the time charge, it does so symmetrically from all possible 3-dimensional spatial positions, and at the center of mass or at the time charge itself, space self-annihilates: x cancels -x, y cancels -y, and z cancels -z, leaving behind, of course, a new residue of t, which cannot cancel because there is no -t. The new time charge replaces the old, for it is the unique character of this charge that it is transient (of course!), and must be continuously renewed (as demanded by both the first and second laws), thus producing the continuous one-way flow of time, the continuous one-way flow of gravitation, and a spherically symmetric gravitational field with a local "center of mass". The one-way character of time is a consequence of its ephemeral character, or intrinsic motion. Note that here we have symmetric space chasing asymmetric time, exactly the reverse of the situation producing the intrinsic motion of light. This is just the difference between implicit and explicit time (reminiscent of David Bohm's "implicate and explicate order") [7].

Quantum Mechanics and Gravitation

The collapse of a non-local electromagnetic field produces massive particles in quantum mechanics, and simultaneously produces gravitation in spacetime. In the case of gravitation, the collapse of the spatial, symmetric component of the electromagnetic field leaves a time residue, or time charge, conferring a specific dimensional location or non-zero Interval upon the massive particle. Hence the "location" (gravitational) charge, whose active principle is time, is the dimensional equivalent of any other charge, due to its asymmetric, one-way character. The "graviton" or field vector of this charge is therefore a quantum unit of negative entropy, the transformed intrinsic motion, or entropy debt, of the photon.

The continuous action of gravitation is matter's forceful expression of entropy; time and its intrinsic motion are matter's dimensional expression of entropy. The ephemeral, moving, asymmetric time charge must continuously be replenished by a symmetric inflow of space, creating, in satisfaction of energy conservation, the temporal conservation domain of matter, matter's intrinsic motion in time, and the deceleration of the cosmic expansion. Entropy's positive forceful expression, the intrinsic motion of light, creates space, the dimensional conservation domain of light, illustrating in both cases the stringent connection between the first and second laws of thermodynamics: energy conservation within a dimensional arena of action.

Black Holes and Entropy

The surface area of a black hole is proportional to its entropy [5], [8]. The surface of a black hole is the location at which space is converted completely to time by gravity. The gravitational flow represents the activity of both the first and second laws - the creation of a conserving time dimension for matter and matter's forceful expression of entropy. Ordinarily, as the mass of an object increases, its increased time and entropy requirements can be accommodated by a greater spatial flow - a stronger gravitational field flowing across a given surface area. But in the limiting case of the black hole, a stronger field is not

possible in terms of acceleration, so a larger field, expressed in terms of a larger surface area, is the only accommodation available for additional mass inputs.

Usually we think of gravitation as converging to a central dimensionless point - the center of mass at which the inflowing dimensions symmetrically annihilate each other, leaving the time charge residue. The black hole surface is the expansion of this dimensionless central point to accommodate a greater gravitational flow. The surface is still dimensionless in that there is no spatial volume present - only a "black hole" which displaces ordinary space much as a ship displaces water. However, ordinary volumetric spatial relationships do not apply to the black hole, precisely because there is no internal active or reactive "space". Ordinary volumetric relationships are therefore expressed through surface area relationships, as the surface is the only active contact between spacetime and the mass-energy of the black hole.

Since both the expression of entropy and the expression of time face the same problem in the black hole, the surface area should also bear some relation to the total time dimension of the hole. It seems indeed that the surface of a black hole should consist of pure time. The expansion of the central dimensionless point of gravitational convergence is the expansion of a time surface. In other words, time is the "ship" which is displacing the "water" of space. Hence the rotation of a black hole conserves its angular momentum, its mass conserves raw energy, and its surface area (the space "displaced") is proportional to its mass, time dimension, entropy, and total gravitational field energy. The growth of the radius of a black hole will therefore be controlled by increases in the hole's surface area, not volume, which means very massive black holes will be considerably larger and less dense than we might otherwise suppose.

In the limiting case where g=c, all the relationships between mass, time, space, entropy, and gravitation become reduced to the single common denominator of surface area, since this is the only metric expression of these conserved, quantitative relationships which remains available. It would seem that the quantative relationship among these several variables could not find such a singular physical expression unless they are related in the way we have supposed.

Considering that time is the dimensional driver of entropy, whether for light or matter, we might expect this time surface to be active in furthering the entropic march of one or the other. The black hole, however, is the limiting case for matter's entropic march; the hole can get bigger, but this is not very interesting. If the hole's mass could be converted to light, however, then a new, positive entropic march could begin - much more interesting, and entropy's concern is change, action, evolution. Having driven matter to its negative entropic limit, it would seem that time can now only reverse the entropic flow, and begin anew by converting the hole's mass to light. Indeed, Hawking's theory of the quantum radiance of black holes confirms this suspicion; through Hawking's process, black holes will eventually radiate away their entire mass, completely converting matter to light. It is just at the time surface of the black hole that this activity must occur.

The black hole is an Armageddon of physics, the final battleground between light and matter, space and time, symmetry and asymmetry. In the end, the strong arm of gravitation wins the day, converting matter completely to light, releasing it from its prison in time. By this means gravitation fully repays the symmetry debt of its "location" charge, vanishing time and restoring the metric symmetry and entropic march of light in space.

Summary

The charges of matter are the symmetry debts of light. These charges function to produce forces which return the asymmetric system of matter to its original symmetric state, light. We see gravity fulfilling this role (partially) through astrophysical processes exampled by our Sun, and (completely) through Hawking's quantum radiance of black holes. However, to characterize gravitation as just another of several symmetry debts of light is to oversimplify this complex force and overlook its other conservation roles.

Gravitation is a consequence of light's loss of intrinsic motion c, the fundamental gauge of electromagnetic metric symmetry. Gravitation is the consequence of the non-zero Interval of matter, the loss of light's non-locality and the loss of the distributional symmetry of light's energy. Gravitation is the consequence of the explicit appearance of time, the asymmetric dimension and the active principle of the "location" charge. Gravitation is required by energy conservation and the second law, to provide a time dimension for matter through the conserved expression of light's entropy. Gravitation is the conserved form of light's intrinsic motion. Gravitation is all these; it is its entanglement with the first and second laws that distinguishes gravitation from the other symmetry debts of light.

In all this, the central role of T (time) stands out. During the production of matter (or simply the capture of a photon), light loses its intrinsic motion c and non-local character. The collapse of light's spatial wave function creates an explicit time residue. T provides matter with a specific location in the otherwise symmetric field of space, producing matter's non-zero Interval, and destroying the symmetric distribution of light's energy in space. The asymmetric time residue becomes the active principle of the "location" charge, inducing a symmetric flow of space toward itself as the spatial field tries to neutralize the time asymmetry embedded in its metric. The transient time charge, however, is one-way, and cannot be neutralized by the induced spatial flow; it continuously fades away, only to be replaced by a new time residue produced by the self-cancelling flow of the spatial dimensions. The intrinsic motion of time induces a continuous spatial flow of gravitation which produces a continuous resupply of time, etc., much as the electric and magnetic fields of light continuously induce each other. It is the intrinsic motion or transient nature of the time charge, its continuous fading, which induces the spatial flow or chase. It is this ephemeral nature of the time charge which produces its one-way character. The conservation reason for the motion of time is that matter's energy accounts must be continuously updated, one moment after another, in a causal sequence.

These electric and metric phenomena in fact are related by more than analogy, since light cannot be separated from its conservation domain. The intrinsic motion of light is caused by symmetric space fleeing asymmetric time, whereas the intrinsic motion of gravitation is caused by symmetric space chasing asymmetric time. The relationship between gravitation and quantum mechanics finds one expression in the notion of a quantized time charge inducing the spatial flow we recognize as a gravitational field, with the "graviton" as the quantum unit of negative entropy. Matter's intrinsic motion in space (gravitation) is related to light's intrinsic motion in space by a simple "switch" from implicit to explicit time, triggered by the spatial collapse of light's wave function. This switch produces the time dimension for matter required by energy conservation, and reverses the entropic flow from positive, expansive (for light) to negative, contractive (for matter).

In the case of the quantum radiance of a black hole, we see gravitation fulfilling its role as a symmetry debt, effecting the complete conversion of matter to light, hence restoring the original symmetric energy state of the Universe. While we expect no less from any symmetry debt, we do not see the other charges of matter aggressively engaged in such an active pursuit of their goal - they simply abide and wait for a chance to act. But gravitation actually creates its own chances, and this is gravitation in its entropic role.

The second law exists to allow the Universe to act, change, and evolve, and gravitation fulfills this entropic role for matter, which otherwise would be woefully inert.

In the black hole, gravitation's "purpose" (in the sense of paying its symmetry debt) is apparently to quash the time asymmetry by putting space and time back on an equal footing; if space is replacing the time charge as fast as it fades (by moving at velocity c), then the tension or distinction between asymmetric time and symmetric space disappears. The time charge is replaced so fast that it can no longer be said to be transient, and perhaps in this form time is no longer truly asymmetric. Asymmetric time is again suppressed by symmetric space, just as it was in the original light Universe. One evidence of this "equal footing" is the appearance of time as a "spatial" entity - the volume of space displaced by the time surface of the black hole. It is in this state of the evident cancellation of time's asymmetric character (the analog of the abeyance of gravitational forces during "free fall") that the phenomenon of Hawking's quantum radiance can take place - the quantum "tunneling" of light from the time surface of the black hole.

The energy of gravitation is the transformation of the energy required to produce the intrinsic motion of light. All photons, regardless of their energy content, have the same intrinsic motion, c. The energy required to produce this intrinsic motion will reappear in matter in the amount Gm, where G is the universal gravitational constant and m is the mass equivalent energy of the photon(s) which created m. Hence there must exist the equivalent relation for light, K(hv/cc;), where K is a universal constant, opposite in sign but equal in magnitude to G, which produces the intrinsic motion of light, and hv/cc; is the energy equivalent of m (from Debroglie's relation, hv = mcc; where h = Planck's constant and v = the frequency of light).

Therefore: K(hv/cc;) + Gm = 0

Appendix:

A Further Perspective on the Conversion of Positive to Negative Entropy

Thermal (heat) entropy enables the energy of the Universe to do work (the creation of improbable distributions of energy, materials, and/or information) without violating energy conservation. Heat entropy originates as the intrinsic motion of light; since it is this intrinsic motion that creates space, we can say that space itself has an intrinsic motion, which produces its expansion and cooling, the same intrinsic motion or entropy as the light which creates it. This is the connection between the 1st and 2nd laws of thermodynamics: entropy creates a dimensional conservation domain appropriate for its energy source, in which energy can be transformed as well as conserved.

In the case of matter's negative, or time-entropy, we find that the Universe is enabled to contain matter, also without violating energy conservation (free energy can be transformed to bound energy, because the existence of time allows conservation of matter's energy account). The positive entropy of light and the negative entropy of matter cannot be independent phenomena, because matter is created from light. Nevertheless, in the conversion of light to matter, there is an obvious problem with the conservation of light's entropy, since matter has no intrinsic spatial motion and so cannot participate in the expansion and cooling of space. However, we still expect that light's entropy must somehow be conserved, if it is indeed connected to the first law, as we have supposed.

When light is converted to matter, light's intrinsic motion disappears, but matter acquires a strange, new

intrinsic motion, gravitation. Might this new force be the conserved entropic function of light that we were expecting? Indeed, it is so. The conservation function of gravitation is to produce matter's time dimension; hence it is matter's one-way time-ageing which is the entropic replacement for light's one-way spatial-expansion. As in the case of light's intrinsic motion and space, matter's gravitation creates a dimensional conservation domain, time, appropriate to its energy source. Also like space and light, the time dimension shares the intrinsic motion and entropy of its energy source, gravitation.

In the process of creating matter from light, light's intrinsic motion is converted to matter's intrinsic motion (gravitation). The conservation reason behind this strange conversion is that matter requires a time dimension to balance its raw energy account (because unlike light, matter's energy content varies with its velocity (momentum, kinetic energy)). Gravitation is the force which creates matter's time dimension by consuming space. Producing time directly from space creates a metrically equilibrated, combined, dimensional conservation domain (spacetime), in which both matter and light can coexist, interact, and find conservation. The gravitational substitution of time for space directly embeds matter in the metric, from which it would otherwise be estranged due to its lack of intrinsic motion. In this way, matter acquires an intrinsic motion in time which is the metric equivalent of light's intrinsic motion in space (one second of time duration is metrically equivalent to 186,000 linear miles of space - c, the velocity of light).

Unlike symmetric space, time is an asymmetric, moving dimension; the intrinsic motion of time is the basis of its one-way character. Massive objects have intrinsic motion in time not because they move, but because the dimension moves. Recall that it is possible to move in one dimension of space while remaining stationary in the other two - this is the typical case for linear motion. Since time must be thought of as existing at right angles to all three spatial dimensions simultaneously, it is not difficult to see how objects can always be moving in time whether or not they move in space. The gravitational field of mass connects space and time, creating time by the consumption of space. The one-way character of gravitation is due to the one-way, transient character of time. We have already noted the necessity of a time dimension to keep the raw energy account of matter continuously updated, and it should be intuitively obvious from the example of momentum that this will require a linear, one-way, continuously active accounting system such as time, respecting the principle of causality.

Mass-Time-Charge

There is a curiously interdependent relationship between time, mass, and the information content of matter (charge). Mass acts as an information carrier, but it is information (through charge conservation) which allows mass to manifest. Time is absolutely required for the continuous updating of the raw energy account of mass, and the symmetry-debt charges with their information content appear to "piggy-back" on mass, coming along for the ride through time. Nevertheless, it is charge conservation and not raw mass which makes the excursion into time possible in the first place. Mass plus charge equals matter (since mass by itself has no character); it is the information content of matter (in the form of conserved charges) which allows matter to enter into manifestation, and which is likewise the necessary guide for matter's exit.

While time is necessary for the existence of mass, is also an absolutely necessary feature of charge conservation. The great difference between raw energy conservation and symmetry conservation is that while raw energy conservation must take place immediately, symmetry conservation can be indefinitely delayed through the device of charge conservation. A symmetry debt can be held as a charge for any amount of time until it is finally repaid through annihilation with an anti-charge, as in a

matter-antimatter reaction. But charge conservation allows alternative charge carriers (leptons) to satisfy symmetry conservation, avoiding antimatter annihilations; this is obvious from the example of the electron and proton, which balance each others charges, and will hold their charges forever, but which cannot annihilate each other because they are not each other's antiparticles.

This ability to hold a symmetry debt as a conserved charge, to be repaid at some later, indefinite date, is an essential requirement to bring our Universe into manifestation, rather than condemning it to immediate annihilation by antimatter. Time is the charge-card of the Universe, allowing free energy to appear as mass on the charge-conservation promise that the symmetry debt thus incurred will eventually be repaid. Gravity is simply the energy-interest on this symmetry debt, funding the time dimension by decelerating the expansion of the Universe.

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