Traveling Twin Paradox: Covariance of Space and Time

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Abstract

Clocks measure spacetime, not just "pure" time. Insofar as the intrinsic motion of light and the intrinsic motion of time are the entropy drives of free and bound energy, clocks also measure the march of temporal entropy. A moving clock incorporates space into its time measurements, thus "spacing out" its ticks or temporal intervals in relativistic proportion to its velocity, hence "running slow" (and hence measuring spacetime, not just time). The stationary clock of course does not incorporate any space into its temporal measurement, and so records "pure" time. This was Einstein's great discovery regarding the relative or local nature of time.

Introduction

The "Twins Paradox" is an often cited "thought experiment" illustrating the relativistic slowing of moving clocks and the "local" character of time in Einstein's Special (and General) Theory of Relativity. The effect has been amply demonstrated and confirmed in the laboratory. The paradox involves a traveling and a stationary twin: the traveling twin leaves Earth on a fast spaceship, travels to a distant star, and returns many years later to reunite with his brother who never left home. The paradox consists of the fact that the traveling twin has aged less than his stationary counterpart - how much less depending on how far and fast he has been traveling. As Einstein said, everyone carries his own clock around with him. Your wristwatch measures your personal, local time, including the "relativistic" time of rapid travel. How are we to understand this strange phenomenon?

Einstein said that time is what a clock measures. We begin by asserting that clocks measure spacetime, as well as "pure" time. Furthermore, insofar as the intrinsic motion of light (as gauged by "velocity c") and the intrinsic motion of time (also gauged by "velocity c") are the entropy drives of free and bound energy, clocks also measure the march of temporal entropy. (See: "Spatial vs Temporal Entropy".) A moving clock incorporates space into its time measurements, thus "spacing out" its ticks or temporal intervals in relativistic proportion to its velocity, hence "running slow" (and hence measuring spacetime, not just time). The stationary clock of course does not incorporate any space into its temporal measurement, and so records "pure" time. This was Einstein's great discovery regarding the relative or local nature of time. There is a corresponding spatial contraction (in the direction of motion) due to relativistic velocity (think of the missing space as that which is incorporated into the temporal metric). The actual sensation of a space traveler would not be of slow time, but of shortened distance - the stars would seem nearer than previously believed. (See also: "The Higgs Boson vs the Metric of Spacetime".)

Clocks

Why do (must) clocks behave this way? What is the conservation reason for this flexibility in the dimensional metric? In principle, this flexibility is required to protect the invariance of Einstein's "Interval" and "velocity c", rescuing causality and energy conservation from the shifting perspectives of relativistic motion ("Lorentz Invariance" of Special and General Relativity). (The "Interval" is an invariant measure of spacetime, the same for all observers, regardless of their relative motion, including accelerated motion - hence its utility in protecting the principle of causality, velocity c, and by extension, energy (and charge) conservation.)

The intrinsic motion of light (as gauged by "velocity c") is the entropy drive of free energy, regulating the creation of space, the dimensional conservation domain of light. The intrinsic motion of light also causes the expansion and cooling of space, providing the entropic foundation for free energy's dimensional conservation domain. The intrinsic motion of time (also as gauged by "velocity c") is the corresponding entropy drive of bound energy, regulating the creation of history, the dimensional conservation domain of matter's causal information web, net, field, or "matrix". The intrinsic motion of time causes the aging and decay of matter and the expansion and dilution of historic spacetime, providing the entropic foundation for bound energy's dimensional conservation domain. History is the temporal analog of space. "Velocity T", a secondary (local and variable) gauge regulating the rate of flow of matter's time dimension, is derived from the primary electromagnetic gauge constant "c" as the duration required by light to travel a given distance. (See also: "The Time Train".)

At "velocity c", T = zero, and the entropy component of energy is entirely spatial (clocks stand still at velocity c - light has no time dimension and produces no gravitational field). At "velocity T", matter has no (net) intrinsic spatial motion, produces a gravitational field, and the entropy component of energy is entirely temporal. In both cases, the entropy drives or intrinsic motions of light and matter's time dimension create a dimensional conservation domain (space and historic spacetime) in which energy can be simultaneously used and transformed, but nevertheless conserved. This is the essential connection between the 1st and 2nd laws of thermodynamics (energy conservation and entropy) (see also the discussion of "Gravity and Clocks" below).

Entropy

The function of entropy is to prevent the abuse of energy so that energy may be simultaneously used and conserved. In other words, the second law of thermodynamics (entropy) guarantees to the first law of thermodynamics (the conservation of energy), that in the dimensional domains entropy creates (space and history), energy cannot be abused - for example, entropy guarantees that the same energy cannot be used twice to produce the same net work (forbidding the "perpetual motion machine", or any device that creates net energy). In return, in consideration of this guarantee, the first law allows such use and transformation of energy as is commensurate with energy's conservation and the increase of entropy. The guarantee provided by entropy is in the form of the effectively "infinite" velocities of c and T, which are metric equivalents. These effectively infinite velocities seal the borders of their dimensional conservation domains, preventing causality or energy conservation violations via fast spaceship or "time machine", and producing the expansion and cooling of space, the aging and decay of matter, and the expansion and dilution of historic spacetime, matter's causal information field. The "infinite" velocities of c and T guarantee that the escape of heat and opportunity into space and history are not recoverable by any means. See: "Spatial vs Temporal Entropy".

Because entropy is part and parcel of energy conservation, as we have seen above, it is evident that all forms of electromagnetic energy, whether free or bound (light or matter), must have an entropy drive, whether c or T, or in the case of moving clocks/observers, a mixed entropy drive partly spatial and partly temporal. This mixed entropy drive is necessary to accommodate the additional energy/entropy component of matter that is associated with relative motion rather than rest mass. Massive moving objects pose an energy/entropy problem, because while the energy associated with their *rest mass* is fixed (E = mcc), the energy associated with their *relative motion* is not, depending on the unpredictable motions and positions of arbitrary observers, as well as their actual (accelerated) motion.

Quite unlike the case with light and its constant, absolute (non-relative) motion (as gauged by "velocity c"), we find that because the motion of matter, and hence the energy and entropy associated with this motion, is both relative and unpredictable, the mixed entropy function of moving observers/clocks also needs to be flexible in the relativistic sense, in other words, clocks must be flexible in their rate depending on their relative motion, leading us to the necessity for "proper" or local time for each observer and the variable rate of moving clocks. It is just the mixing of space into the temporal metric by the relative motion of the clock/observer that allows this necessary flexibility. It is because we live in a joint dimensional conservation domain of free and bound (light and matter) electromagnetic energy (spacetime) that the variable rate of clocks is both possible and necessary. Without such flexibility in the time dimension, matter could not move in space because its energy/entropy accounts could not be tallied and conserved. These considerations do not apply to the motion of massless light, which has no time dimension, and can move only at the invariant, non-relative (absolute) velocity "c". According to the canon of special relativity, light's velocity is invariant, regardless of the relative motion of light's source or observer. Unlike matter, the energy of light varies not with its velocity, but with its frequency. The same arguments from Special Relativity that require time for the accounting of matter's energy in motion, apply also to the accounting of the causal relations of moving matter, the sequence of cause and effect which is such an important part of energy conservation in the case of local, massive energy forms.

The invariance of the universal electromagnetic energy constant or gauge "c" is necessary for any number of reasons directly and indirectly involving energy conservation, including the conservation of causality, charge, inertial and metric symmetry, the mass vs free energy equivalence relation (E = mcc), etc. The metric covariance between slowing clocks and shrinking meter sticks of Einstein's Special and General Relativity which guarantees the invariance of velocity c is also known as the phenomenon of "Lorentz Invariance".

Gravity and Clocks

One further matter needs to be discussed, and that is the entropic role of gravitation and the gravitational effect on time. One of gravity's roles is the conservation of the primordial drives of spatial and temporal entropy in transformations between free and bound energy forms (in either direction). Gravity converts space and the drive of spatial entropy (the intrinsic motion of light) to time and the drive of historical entropy (the intrinsic motion of time), and vice versa. Gravity creates time (or temporal entropy) through the annihilation of space and the consequent extraction or release of a temporal residue - the metric equivalent of the space consumed (see: "The Conversion of Space to Time"). Gravity creates time and spacetime, the joint dimensional conservation domain of free and bound energy. In the reverse reaction, gravity creates light and space (or the drive of spatial entropy), by the conversion of bound energy to free energy in stellar processes and the "quantum radiance" of black holes, conserving the "non-local" symmetry of light as required by Noether's Theorem. This is the entropic relationship between the three dimensional intrinsic motions, c, T, and G. (See: "The Tetrahedron Model.")

The universal gravitational constant G is the gauge regulating the conversion of the drive of primordial spatial entropy (the intrinsic motion of light), to the drive of primordial historical entropy (the intrinsic motion of time), and vice versa. The magnitude of G tells us how much space must be converted to time to supply the temporal entropy drive of any given mass. "Gm" measures the temporal entropy-energy of m, or the energy required to create m's time dimension via the gravitational annihilation of space. See: "Gravity, Entropy, and Thermodynamics" and "The Double Conservation Role of Gravitation".

Because gravity is the actual accelerated flow of space, the effect of gravity on clocks is the same as that of a clock accelerating through space - "moving clocks run slow", and so gravity also slows clocks because space is moving through them (as per Einstein's "Equivalence Principle"). For co-movers (free fall, orbit), the field vanishes and clocks are seen to run normally. (See also: "The Higgs Boson vs the Metric of Spacetime".)

Gravity is weak because gravitational energy is entropy-energy. "Gm" measures the energy required to create m's time dimension. The gravitational conversion of spatial to temporal entropy via the annihilation of space causes a deceleration in the expansion rate of the Universe, while the reverse process (the astrophysical conversion of mass to light) of course reduces the deceleration (producing the perception of an "accelerating Universe"). In either case, the entropy of the Cosmos, whether temporal or spatial, continues to increase, since both are positive parameters. (For an explanation of the weakness of gravity, see: "The Half-Life of Proton Decay and the 'Heat Death' of the Cosmos".)

The magnitude of G is determined by the small energy difference between the symmetric spatial entropy drive (S) of light (the intrinsic motion of light, as gauged by "velocity c"), and the asymmetric historical entropy drive (T) of matter (the intrinsic motion of matter's time dimension, also as gauged by "velocity c"):

$$S - T = -G.$$

This is equivalent to the small energy difference between implicit (S) and explicit (T) time. (See: "The Conversion of Space to Time".)

The gravitational conversion of space and the drive of spatial entropy (S) (the intrinsic motion of light) to time and the drive of historical entropy (T) (the intrinsic motion of time), can be represented symbolically in a "concept equation" as:

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

The gravitational deceleration of the cosmic spatial expansion provides the entropy-energy to produce matter's time dimension. Hence it is ultimately the spatial entropy drive of light that funds the historical entropy drive of matter. Gravity pays the entropy-"interest" on the symmetry debt of bound electromagnetic energy via the creation of matter's time dimension (in which charge conservation can have meaning), funded by the deceleration of the spatial expansion of the Cosmos, in other words, by the entropy drive of free electromagnetic energy. Gravity pays the energy-"principle" of matter's symmetry debt by the conversion of bound to free energy in stars (partially), and via Hawking's "quantum radiance" of black holes (completely), vanishing both mass and its associated gravitational field. (See: "A Description of Gravity", and "Proton Decay and the "Heat Death" of the Cosmos".)

Accelerated Motion and Clocks

If neither twin has experienced accelerated motion, the effects on the local metric are simply relative and reciprocal: each twin sees the other as younger, that is, as aging more slowly, because each sees the other's moving clock running equally slowly (this is possible so long as they only see each other in passing (reciprocal exchange of light rays) and never actually decelerate and physically meet each other). Acceleration, however, produces non-relative, permanent, or absolute change in the local metric, due to the directed application of energy (as in a rocket ship or a gravitational field). Acceleration is the equivalent of laying hands on the clock mechanism to slow its action, an effect we feel as inertial force or gravitational "weight". Because energy has been expended upon the local metric itself, permanent change results. Thus the traveling twin experiences four periods of acceleration (once leaving, twice turning around, and once returning to Earth), while the stationary twin experiences none, effecting an absolute (non-reciprocal) change in the traveling twin's aging process (temporal entropy drive or local clock). Thus the actual reason why the returning twin has aged less than his stationary brother is because some of the traveling twin's primordial, dimensional entropy drive has been experienced spatially, rather than temporally, whereas all of the stationary twin's primordial, dimensional entropy drive has been experienced temporally. (See also: "The Time Train".)

Acknowledgment:
This paper was developed in response to a paper on a similar topic by Dr. Richard D. Stafford:
Resolution of the Relativity/Quantum Mechanics Conflict

Links:

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Gravity Diagrams

A New Gravity Diagram
The Gravity Diagram
The Three Entropies: Intrinsic Motions of Gravity, Time, and Light

References:

Robert Resnick: Introduction to Special Relativity. 1968. John Wiley and Sons, Inc.
Dr. Richard D. Stafford's Spacetime Map (text)
Dr. Richard D. Stafford's Spacetime Map (diagram)

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