THE RELATIVITY OF MASS-ENERGY AND MOMENTUM

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In the latter half of the 19th century light became viewed as the propagation of electromagnetic waves of energy through a sea of ether. In contrast to the relative motion of material objects simply being relative to each other, all light propagates through the ether at the same speed, as according to theory, providing that it does not also propagate through a material medium as well, such as through glass, water or a gravitational field. It was thus believed the ether was a particular state of existence in relation to light speed that could be designated as absolute rest to which all other motion could compare.

Experiment after experiment failed to detect absolute rest. What the results indicated instead was that light speed is the same no matter what is the velocity of the source or the observer. No adequate theory to explain them was established until 1905 when Albert Einstein's paper on it was published in a journal. Electrodynamics and the mechanical laws of motion were thereby unified, as modifying Galilean relativity according to Einstein's special theory of relativity.

Einstein founded special relativity theory on two postulates. The first one is with regard to the constant nature of light speed. The second one is referred to as the principle of covariance. Covariance means the laws of physics are the same no matter what is the velocity of the system they are determined from. A second, for example, is the same no matter what velocity the observer and the observer's clock move at relative to another observer, but the second is relatively longer if the clock moves relative to the observer instead of with the observer. Light speed is itself covariant, as being the same to all observers, but a distinct property of it is it has the same speed everywhere in vacuum space whereas particles of matter vary in speed.

Instead of light speed varying according to the relative motion of the observer what varies instead are the clocks and measuring rods used to measure space and time—such that the variance depends only on the relative motion between the observer and the measuring device and not on any particular state of motion designated as absolute rest.

Instead of the ether being the special reference frame to refer all other relative motion to, constant light speed is the determining factor. The conditions of nature are modified to comply. Instead of calculating variable light speed to offset relative effects of nature on space and time, space and time are no longer absolutes. They vary instead in such a way that light speed is the same for any velocity of events and any velocity of the observer who measures them.

Along with covariance came paradoxes. A famous one is the clock paradox whereby two observers moving relative to each other determine each other's clock as slow. Nonetheless special relativity theory remains a mathematically consistent theory in agreement with observation. All of its formulation, as with regard to the mathematical derivation of further principles and theorems, is consistent with the two postulates that had been founded on fact of observation and experiment. Further derivation by algebra produced the addition of velocities theorem and so on. By the addition of velocities theorem, in particular, it is determined that matter can neither equal nor exceed light speed.

Another paradox less publicized than the well-known clock one is with regard to relative mass. Similar to a clock in relative motion being relatively slow, mass in relative motion is relatively greater than if it is relatively at rest, but relative mass is also derived with the condition that total mass is conserved by way of inelastic collision. That is to say, if you change speed by way of inelastic collision with an asteroid, the total mass of you and the asteroid does not change, but all mass everywhere apart from the collision does change due to your change in relative motion.

The condition of mass as relative is consistent with theory and in agreement with observation. Its derivation is now reviewed with regard to the inelastic collision of mass obeying the laws of conservation of mass and conservation of momentum. Verification by example is provided by comparing results of two equal relative masses in inelastic collision with specified velocities.

Examples for more general conditions, as with regard to unequal masses in either inelastic or elastic collision are also given. A particular example is with regard to elastic collision, which involves the process of an inelastic one plus its reverse process. Although the reverse process is opposite to inelastic collision, it differs inasmuch as an exchange of mass occurs whereas masses in inelastic collision merely combine to become one mass.

Mass can also accelerate by it absorbing, emitting and reflecting light. The derivation of Einstein's famous mass-energy equation, $E = mc^2$, is thus reviewed as well. In addition, it is showed by example how relative mass is able to exchange mass-energy with light by either reflecting it, or absorbing and emitting it in analogy to inelastic and elastic collision.

Relative mass and momentum are conserved with regard to both inelastic and elastic collision between masses. They are further conserved with regard to the reflection, absorption and emission of light by matter. Gravity, however, is another matter.

In Newtonian Mechanics, whereby space and time are assumed to be absolute conditions of nature, conservation of momentum is simply maintained the gravitational attraction being mutual between masses. A change in momentum of the moon caused by Earth's gravity thus equals a change in momentum of Earth caused by the moon's gravity, whereby a change in velocity of the Earth's greater mass is far less than the more noticeable change in velocity of the moon's smaller mass. The moon thus circles around Earth's smaller orbit around the center of mass. However, although the Earth and the moon mutually attract each other, they never actually come into direct contact with each other, such that Newton's law of gravity is only explained as an action at a distance principle.

In contrast, Einstein's general theory of relativity does not merely modify Newton's inverse square law of gravity for it to comply with the conditions of relative space-time; it avoids action at a distance by way of a unique interpretation of a principle on which the theory is formulated, the equivalence of inertial and gravitational mass. According to Einstein's own interpretation of the principle an observer in free fall has no internal awareness of acceleration. All mass-energies simply follow the path of a space-time continuum that the presence of mass curves. Therefore, the conservation laws of momentum and relative mass-energy that apply in

accordance with special relativity theory apply to space-time curvature as well.

Unfortunately space-time curvature is not as simple as is relative motion. Portions of space-time curvature relate to a general distribution of mass at large instead of only between two particular masses, such that tidal effects occur. For instance, the ocean tides relate to the moon being closer to one side of Earth than the other. Earth observers are thus aware of internal effects of Earth's free fall towards the moon. In effect, there is an enormous complexity involved with Einstein's general field equations. Super computers are now used to solve them.

Since the mathematics of general relativity is extremely complex, the focus here is to elaborate on its fundamental principles. Newton, for instance, refused to declare his inverse square law of gravity as universal throughout the universe. He left open the possibility that gravity differs in other solar systems. It became accepted as universal nonetheless, except by a few challengers. Ernst Mach, in particular, offered the principle that inertial of matter is somehow dependent on the total distribution of all other mass in the universe. There is thus the possibility that inertial mass differs from gravitational mass. However, the theory of general relativity interprets the Mach according to the principle of equivalence along with a more general principle of covariance.

The principles of equivalence and general covariance can be easily explained philosophically. Somewhat more challenging is how to explain how the presence of mass determines space-time curvature. The theory of general relativity describes stress conditions of the space-continuum in relation to mass-energy, but there are some conceptual difficulties. Light approaching Earth, for instance, somehow increases in energy by way of the presence of mass. By Einstein's unique interpretation of the principle of equivalence there is no increase in energy relative to an observer in free fall with the light, as the increase in energy occurs instead relative to an observer on the surface of Earth who resists free fall. Light energy thus increases because the Earth observer accelerates toward it. This result is analogous to the simpler conditions of special relativity theory. However, to explain the increase in energy in view of how the presence of mass results in space-curvature is more difficult to explain.

Another paradox is how light energy approaching Earth increases in view no information of events exceeds light speed according to special relativity theory, such that light is unable to mutually attract Earth until it gets to Earth. Moreover, if the increase in energy is by way of a graviton or some other direct action, there is a paradox as to how the graviton can continue forward unimpeded to attract other matter such that there is a direct change in momentum of matter in one direction without a direct compensation of it in the opposite direction.

Conditions of general relativity with regard to how momentum of gravitational energy is conserved by way of stress on space-time are thus subject to speculation. That is to say, since something acts on space-time to cause its curvature, space contains some form of energy. The existence of a plasmatic state of equilibrium, for instance, could very well cause the gravitational effect whereby contiguous action occurs in manner of being consistent with space-time curvature, conservation of momentum, and conservation of relative-mass energy.

This plasmatic explanation of gravity is speculative and *ad hoc* in that it explains the cause of gravity according to established theory, but it nonetheless serves its purpose, which is to provide a more down to Earth way of understanding theory.

Verification of Relative Mass

A collision is inelastic if masses stick together after their collision with each other. Classical Newtonian Mechanics assumes the total mass and momentum are the same before and after the collision. These two conservation laws are also conditional to relativity theory. Paradoxically, however, also according to relativity theory the mass m in relative motion at velocity v in ratio to light speed c is relatively greater than the same mass m_0 relatively at rest, as according to the equation

$$m = \frac{m_0}{\sqrt{1-\left(\frac{v^2}{c^2}\right)^2}} \tag{1}$$

Therefore, if the observer accelerates apart from mass initially at rest with the observer, then it relatively increases and is not conserved.

Despite this paradox relative mass is mathematically verifiable by assuming both conservation of mass and conservation of momentum. The postulates of special relativity theory, as with regard to constant light speed and the principle of covariance, also apply, as does the addition of velocities theorem.

Relative mass is first distinguished from rest mass. Let m_0 be a quantity of mass relatively at rest with either observer A or observer B. Let m be the same mass moving with observer B at velocity v_1 relative to the positive direction of observer A.

The relative mass m and the rest m_0 become one, say M, relative to observer A by way of inelastic collision. Both conservation of relative mass and conservation of total momentum apply, as in accordance with equations (2) and (3) below.

$$\mathrm{m} + \mathrm{m}_0 = \mathrm{M} \tag{2}$$

$$\mathrm{mv}_1 + \mathrm{m}_0(0) = \mathrm{mv}_1 = \mathrm{M}v_2 \tag{3}$$

Equation (2) simply shows the total mass of two separate masses m and m_o relative to observer A before the inelastic collision are the same total mass M relative to observer A after the collision.

Equation (3) is somewhat more complex inasmuch as momentum is mass times velocity. Total momentum is the sum of all momentums of the two masses moving in either the same or the opposite direction. By conservation of momentum it is the same after a collision as it was before the collision. In inelastic collision, momentum of one mass moving in one direction negates the momentum of the other mass moving in the opposite direction, as both before and after the collision relative to say observer C with which they then move. Since equation (3) is with regard to inelastic collision between two masses whereby mass $m_0(0)$ before the collision is relatively at rest with observer A, its momentum relative to A is zero. Therefore, the total momentum relative to observer A before the collision is only mv_1. Since both masses move at velocity v_2 with observer C after the collision, the total momentum relative to observer A is Mv_2, which by equation (3) is the same as mv_1 before the collision.

By conservation of momentum of an inelastic collision the change, which is denoted by the symbol Δ, of momentum in one direction equals the same amount of change of momentum in the opposite direction

$$\Delta m v_1 = \Delta m_0(0) \tag{4}$$

Since mass in conserved and does not therefore change in amount, the change is with regard to the difference in velocities of the masses:

$$\Delta v_1 = v_1 - v_2 \tag{5}$$

$$\Delta v_0(0) = v_2 - 0 = v_2 \tag{6}$$

The changes in velocities are still conditional to equation (4). Hence

$$m(v_1 - v_2) = m_0(v_2 - 0) = m_0 v_2$$

$$\frac{m}{m_0} = \frac{v_2}{v_1 - v_2} \tag{7}$$

Equation (7) can also be obtained by substituting m and m_0 in equation (2) for M in equation (3):

$$m v_1 = (m + m_0) v_2 \tag{7.1}$$

$$m v_1 = m v_2 + m_0 v_2 \tag{7.2}$$

$$m v_1 - m v_2 = m_0 v_2 \tag{7.3}$$

$$m(v_1 - v_2) = m_0 v_2 \tag{7.4}$$

$$\frac{m}{m_0} = \frac{v_2}{v_1 - v_2} \tag{7}$$

The ratio of mass thus equals the inverse ratio of its changes in velocities.

Since equations (1) and (7) differ in form the objective here is to show that they are equal:

$$m = \frac{m_0 v_2}{v_1 - v_2} = \frac{m_0}{\sqrt{1-\left(\frac{v_1}{c}\right)^2}} \tag{8.1}$$

$$\frac{m}{m_0} = \frac{v_2}{v_1 - v_2} = \frac{1}{\sqrt{1-\left(\frac{v_1}{c}\right)^2}} \tag{8.2}$$

Proof of (8.1) or (8.2) is accomplished by converting v_2 in terms of v_1 and thereby showing the resulting form of the middle part of the equation is the same as on the far right side of the equation. In so doing the principle of covariance and the addition of velocities theorem apply.

The addition of velocities theorem, as for velocities in either the same or opposite direction, is of the form

$$v_{12} = \frac{v_1 + v_2}{1 + \beta_1 \beta_2} \tag{9}$$

In equation (9), $\beta_1 = v_1/c$ and $\beta_2 = v_2/c$. The velocity v_{12} is of one observer moving relative to another, say observer B moving relative to observer A. It is also the velocity in relation to say observer C moving at velocity v_1 relative to observer A and the velocity v_2 of observer B moving relative to observer C. (Because clocks and other measuring devices differ because of their relative motion, the addition of velocities does not simply add up as $v_1 + v_2$.)

Instead of eliminating v_2 from equation (7), equation (9) adds v_{12} instead. However, since the velocity of observer B moving relative to observer A has already been denoted as v_1, it is simply substituted for v_{12}. Furthermore, it can be shown that the velocity v_1 of observer C moving relative to observer A is the same as the velocity v_2 of observer B moving relative to observer C.

The reason observer C moving relative to observer A is the same as observer B moving relative to observer C is because of covariance and symmetry. As by equation (3), after the inelastic collision, the velocity v_2 of M moving relative to observer A is zero relative to observer C moving at velocity v_2 relative to observer A. As by equation (9), the velocity of observer B moving relative to observer C is also v_2. (By covariance and by equation (1), observer B perceives the mass from observer A as relatively greater. In order not to be able to distinguish which mass is actually the

greater one, observer C perceives both masses as equally the same. Since momentums in opposite directions cancel each other out, since relative mass is the same from both directions, the velocities are merely opposite in direction. The velocity of observer A relative to observer C are merely opposite as well. Since the velocity of observer B is v_2 relative to observer B, the velocity of observer A relative to observer C is $-v_2$, and because of covariance the velocity of observer C relative to observer A is v_2.)

Hence, by way of substituting v_1 for v_{12} and v_2 for v_1 equation (9) acquires the form

$$v_1 = \frac{2v_2}{1+\beta_2^2} \tag{10}$$

The elimination of v_2 is accomplished by substituting the right side of the equality of equation (10) into equation (8.1), obtaining

$$m = \frac{m_0 v_2}{v_1 - v_2} = \frac{m_0}{\frac{2v_2}{1+\beta_2^2} - v_2} \tag{11.1}$$

Dividing the left and right sides of the equation by m_0 gives

$$\frac{m}{m_0} = \frac{v_2}{\frac{2v_2}{1+\beta_2^2} - v_2} \tag{11.2}$$

By dividing both the numerator and the denominator of the fraction on the right side of the equation (11.2) by v_2 it becomes

$$\frac{1}{\frac{2}{1+\beta_2^2} - 1} \tag{11.3}$$

By multiplying both the numerator and the denominator of (11.3) by $(1+\beta_2^2)$ it becomes

$$\frac{1+\beta_2^2}{2-(1+\beta_2^2)} = \frac{1+\beta_2^2}{1-\beta_2^2} \tag{11.4}$$

The denominator of the fraction on the right side of (11.4) equates as

$$[(1-\ \beta_2^2)^2]^{\frac{1}{2}} = \sqrt{1-2\beta_2^2+\beta_2^4}$$

$$= \sqrt{1+2\beta_2^2+\beta_2^4-\ 4\beta_2^2}$$

$$= \sqrt{(1+\beta_2^2)^2-4\beta_2^2} \qquad (11.5)$$

By substituting the far right side of equation (11.5) for $(1-\ \beta_2^2)$ in equation (11.4) the far right side of equation (11.4) becomes

$$\frac{1+\beta_2^2}{1-\ \beta_2^2} = \left[\frac{(1-\beta_2^2)^2}{(1+\beta_2^2)^2}\right]^{-\frac{1}{2}} = \left[\frac{(1+\beta_2^2)^2-\ 4\beta_2^2}{(1+\beta_2^2)^2}\right]^{-\frac{1}{2}}$$

$$= \left[1-\frac{4\beta_2^2}{(1+\beta_2^2)^2}\right]^{-\frac{1}{2}} \qquad (11.6)$$

The fraction on the far right side of (11.6) equates in the manner

$$\frac{4\beta_2^2}{(1+\beta_2^2)^2} = \left[\frac{2\beta_2}{1+\beta_2^2}\right]^2 = \frac{1}{c^2}\left[\frac{2v_2}{1+\beta_2^2}\right]^2 \qquad (11.7)$$

The fraction in the bracket on the far right side of equation (11.7) is by equation (10) the same as v_1. By substitution (11.7) becomes

$$\frac{v_1^2}{c^2} = \beta_1^2 \qquad (11.8)$$

By substituting (11.8) for the fraction on the far right side of equation (11.6) the quantity of (11.6) becomes

$$\left[1-\frac{4\beta_2^2}{(1+\beta_2^2)}\right]^{-\frac{1}{2}} = \frac{1}{\sqrt{1-\beta_1^2}} \qquad (11.9)$$

Since the far right side of (11.6) equals the far right side of (11.4), which also equals (11.3) and (11.2), which equals the fraction of m/m_0, relative mass is thereby derived by way of conservation of mass and conservation of momentum:

$$m = \frac{m_0}{\sqrt{1-\beta_1^2}} \tag{12}$$

Equation (12) is identical in form to equation (1) except v in equation (12) is specified as v_1.

Verification by Example

Verification of relative mass in view of conservation of mass and conservation of momentum was specifically with regard to an inelastic collision between two equal rest masses moving relative to each other. A more general verification includes any collision, whether it is inelastic or elastic, between any two masses. The general proof is more complicated. Verification by way of specific examples is here preferred instead.

The verification begins with a more specific example between two equal rest masses. Let m_0 = 1 unit of mass, grams or whatever. Let c also be unity, as one unit of distance per unit time. Let m be the rest mass m_0 in relative motion, as moving either from observer B towards observer C at say v_{bc} = .6c or from observer A towards observer C at v_{ac} = -.6c. After an inelastic collision between two equal rest masses from observers A and B the total mass is $2m_c$ relatively at rest as perceived by observer C.

With the velocity of observer A relative to observer C given as v_{ac} = -.6c, the mass $2m_c$ is determined in accordance with equation (1) as

$$2m_c = \frac{2m_0}{\sqrt{1-(.6c)^2}} = \frac{5}{2} \text{ units}$$

Momentum of inelastic collision is conserved relative to observer C because it is zero both before and after the collision, being momentum of one mass merely cancels the momentum of an equal mass moving at the same speed in the opposite direction.

To relate the same event relative to observer A instead of relative to observer C the addition of velocities theorem is applied in order to first determine the velocity of observer B relative to observer A as

$$v_{ba} = \frac{v_{ca} + v_{bc}}{1 + \frac{v_{ca}v_{bc}}{c^2}} = \frac{.6c + .6c}{1 + (.6)(.6)} = \frac{1.2}{1.36}c = \frac{15}{17}c$$

The units of relative mass m from observer B relative to observer A is thus

$$m = \frac{m_0}{\sqrt{1 - \frac{v_{ba}^2}{c^2}}} = \frac{1}{\sqrt{1 - \left(\frac{15}{17}\right)^2}} = \frac{17}{8}$$

The total units of mass before and after the inelastic collision relative to observer A is

$$m + m_0 = \frac{17}{8} + 1 = \frac{25}{8}$$

The total units of momentum before the collision relative to observer A is

$$mv_{ba} = \left[\frac{17}{8}\right]\left[\frac{15}{17}\right] = \frac{15}{8}$$

The total units of momentum after the inelastic collision relative to observer A is

$$(m + m_0)v_{ca} = \left[\frac{25}{8}\right]\left[\frac{3}{5}\right] = \frac{15}{8}$$

Momentum by way of conservation of mass is therefore conserved in inelastic collision relative to observer A.

Elastic collision is the same as inelastic collision plus the reverse of inelastic collision. The event of two equal masses colliding elastically head on at the same speeds relative to observer C is symmetrical in that the

two masses relative to observer C recede from the collision in opposite directions than what they approached observer C at before the collision. The momentum mv_{bc} = - m_{ac} thus becomes mv_{cb} = - mv_{bc} = mv_{ac} and the momentum mv_{ac} becomes mv_{ca} = - mv_{ca} = m_{bc}.

The event is also symmetrical relative to observers A and B except for the added condition of an exchange of mass occurring between m and m_0 by way of the collision is more evident. The reversal of momentums and masses relative to observer A, for instance, is from mv_{ba} to $m_0(0)$ and from $m_0(0)$ to mv_{ba}. Observer C does not detect an exchange of mass only because both masses are still the same after the collision as they were before it occurred. Momentum in elastic collision is thereby conserved by way of an exchange of mass.

This process of exchanging relative mass is further verifiable with regard to the collision between two unequal masses.

Consider an inelastic-elastic collision of two unequal masses. Mass m_{xb} is the amount of mass units as perceived by observer B relatively at rest with them. They move at velocity v_{ba} = .8c relative to observer A to collide with unit mass m_0 = 1, as perceived by observer A relatively at rest with it. After inelastic collision the two masses are relatively at rest with observer C moving at velocity v_{ca} = .6c relative to observer A. After elastic collision, in consequence of the momentums being equal in magnitude relative to observer C before and after their elastic collision, the two new masses merely reverse direction with the same speeds they had before the collision.

Because the inelastic-elastic collision occurs with unequal masses, they also have different speeds, and because of the addition of velocities theorem, the speeds and relative mass of the new masses will not be the same relative to observer A after the elastic collision as they were before it. Therefore, to verify conservation of relative mass and conservation of momentum, what is to be determined from the values given above are these other values

- The rest mass m_{xb} relative to observer B, as with it and observer B both moving towards observers A and C
- The relative mass m_{xbc} of m_{xb} relative to observer C, as moving towards observer C before colliding with m_0

- The velocity v_{bc} of m_{xbc} moving relative to observer C before the collision
- The velocity v_{cb} of m_{xbc} moving relative to observer C after elastic collision
- The relative mass m_{xba} of m_{xb} relative to observer A, as moving towards observer A before colliding with m_0
- The relative mass m_{xbab} of m_{xb} relative to observer A, as moving away from observer A after an elastic collision with rest mass m_o
- The velocity v_{ab} of m_{xbab} moving relative to observer A
- The relative mass m_{0cc} relative to observer A, as the new mass of m_0 of it moving after elastic collision with mass m_{xba}
- The velocity v_{caa} of m_{0cc} moving relative to observer A

Verification of conservations of momentum and of relative mass are achieved by showing they are the same relative to observer A before and after the elastic collision, as from where momentum is conserved by inelastic collision by way of conservation of mass:

$$m_{xbab} + m_{0cc} = m_{xba} + m_0 \tag{13.1}$$

$$m_{xbab}v_{ab} + m_{0cc}v_{caa} = m_{xba}v_{ba} \tag{13.2}$$

$$m_{xba}v_{ba} = (m_{xba} + m_0)v_{ca} \tag{13.3}$$

The value of m_{xb} as the units of rest mass m_0 relative to observer B is calculated by way of the condition that both momentum and total mass are conserved in inelastic collision. Since the rest mass is m_0 = 1 relative to observer A is with regard to the velocity v_{va} = .8c, it is further calculated in the manner of equation (12), where c = 1 is now used:

$$\frac{.8m_{xb}}{\sqrt{1-(.8)^2}} = .6\left[\frac{m_{xb}}{\sqrt{1-(.8)^2}} + 1\right]$$

$$\frac{.8m_{xb}}{.6} = .6\left[\frac{m_{xb}}{.6} + 1\right]$$

$$\frac{4}{3}m_{xb} = m_{xb} + \frac{3}{5}$$

$$\frac{m_{xb}}{3} = \frac{3}{5}$$

$$m_{xb} = \frac{9}{5}$$

The velocity v_{bc} of m_{xc} of observer B moving relative to observer C is calculated according to the addition of velocities formula, as with the numerical value given for the velocity v_{ca} = .6c of observer C moving relative to observer A plus the value v_{bc} of observer B moving relative to observer C in relation to the numerical value v_{ba} = .8c given of observer B moving relative to observer A:

$$.8 = \frac{v_{bc}+.6}{1+.6v_{bc}}$$

$$.8(1 + .6v_{bc}) = v_{bc} + .6$$

$$\frac{4}{5} + \frac{12}{26}v_{bc} = v_{bc} + \frac{3}{5}$$

$$\frac{1}{5} = \frac{13}{25}v_{bc}$$

$$v_{bc} = \frac{5}{13}$$

With this numerical value of velocity along with the value of m_{xbc} is

$$m_{xbc} = m_0 \frac{9/5}{\sqrt{1-\left(5/13\right)^2}} = m_0 \frac{9/5}{\sqrt{\frac{169}{169}-\frac{25}{169}}} = m_0 \frac{9/5}{\sqrt{\frac{144}{169}}} = \frac{9/5}{12/13} = \frac{117}{60}m_0$$

The $m_{xc}v_{bc}$ units of momentum of relative to observer C are thus

$$m_{xc}v_{bc} = \left(\frac{117}{60}\right)\left(\frac{5}{13}\right) = \frac{3}{4}$$

These units of momentum are simply the product of relative mass and velocity relative to observer C before the inelastic collision occurred.

The values of relative mass m_{0ac} and relative momentum $m_{0ac}v_{ac}$ relative to observer C with respect to the rest mass m_o relative to observer A are calculated according to the velocity v_{ac} = -.6c of observer A moving relative to observer C:

$$m_{0c} = \frac{m_0}{\sqrt{1-(.6)^2}} = \frac{5}{4}m_0$$

Since observer C moves at .6c relative to observer A, observer A moves at -.6c relative to observer C, and the number of m_0v_{ac} units of momentum relative to observer C, with the mass m_0 calculated relative to observer C, is thus

$$m_0v_{ac} = \frac{-.6m_0}{\sqrt{1-(.6)^2}} = \frac{-.6}{\sqrt{1-.36}} = \frac{-.6}{\sqrt{.64}} = -\frac{.6}{.8} = -\frac{3}{4}$$

The two momentums relative to observer C are thus of equal magnitude and opposite in direction before the collision. The total momentum of the masses is zero before and after inelastic collision and thus conserved, as is the relative mass with respect to observer C. As for elastic collision, the two masses merely reverse direction to maintain equal speed, mass and momentum both ways.

What is now to be determined from these values is conservation of relative mass and momentum relative to observer A.

To determine equation (13.3) the relative mass m_{xba} of rest mass m_{xb} is calculated in the manner of equation (12). Since v_{ba} is given as .8c relative to observer A, the units of mass m_{xb} relative to A is

$$m_{xba} = \frac{m_{xb}}{\sqrt{1-\left(\frac{v_{ba}}{c}\right)^2}} = \frac{9/5}{\sqrt{1-\left(\frac{4}{5}\right)^2}} = \frac{9/5}{3/5} = 3$$

Substituting this value along with .8c for v_{ba}, 1 for m_0, and .6c for v_{ca} into equation (13.3) gives

$$(3)(.8) = (3+1)(.6)$$

Total momentum of the total mass $m_{xba} + m_0$ before and after an inelastic collision being .24 units on both sides of the equation it is thus conserved relative to observer A.

To verify equation (13.1) is to show the total mass after the elastic collision is still 4 units relative to observer A as it was before the collision. Unlike inelastic collision there is an exchange of relative mass by way of elastic collision such that equation (12) applies along with the addition of velocities theorem. Since the speeds of the masses are simply reversed in direction relative to observer C, such that $-v_{ac}$ as the reverse of observer C moving relative to observer A becomes the same as observer C moving relative to observer A, the velocity of m_{0cc} moving relative to observer A in proportion to light speed is

$$v_{0caa} = \frac{-v_{ac} + v_{ca}}{1 - \frac{v_{ac}v_{ca}}{c^2}} = \frac{2v_{ca}}{1 + \left(\frac{v_{ca}}{c}\right)^2} = \frac{2(.6c)}{1 + (.6)^2} = \frac{1.2}{1.36} = \frac{15}{17}$$

The mass m_{0cc} relative to observer A after the collision is thus

$$\frac{m_0}{\sqrt{1 - \left(\frac{15}{17}\right)^2}} = \frac{17}{8} m_0$$

Likewise, since the velocity v_{bc} before the collision was (5/13)c relative to observer c, it becomes v_{cb} = -(5/13)c after the collision. The velocity v_{ab} of m_{xbab} moving in proportion to light speed relative to observer A is thus

$$v_{ab} = \frac{v_{ca} + v_{cb}}{1 + \frac{v_{ca}v_{cb}}{c^2}} = \frac{\frac{3}{5}c - \frac{5}{13}c}{1 - \frac{3}{13}} = \frac{7}{25}$$

The relative mass m_{xbab} relative to observer A after the collision is thus

$$\frac{m_0}{\sqrt{1-\left(\frac{v_{ab}}{c}\right)^2}} = \frac{\frac{9}{5}m_0}{\sqrt{1-\left(\frac{7}{25}\right)^2}} = \frac{\frac{9}{5}m_0}{24/25} = \frac{15}{8}m_0$$

Since $m_0 = 1$, the total units of mass after the collision are

$$\frac{17}{8} + \frac{15}{8} = \frac{32}{8} = 4$$

Since the total units of mass are 4 before and after the collision, equation (13.1) is thereby verified.

The number of momentum units relative to observer A before the collision was

$$m_{xba}v_{ba} = (3)\left(\frac{4}{5}c\right) = \frac{12}{5}c$$

After the collision they are

$$m_{xbab}v_{ab} + m_{0aa}v_{caa} = \left(\frac{7}{25}\right)\left(\frac{15}{8}c\right) + \left(\frac{17}{8}\right)\left(\frac{15}{17}c\right) = \frac{12}{5}c$$

Since the total units of momentum are the same after collision as they were before it occurred, equation (13.2) is therefore verified.

Mass-Energy and Light

Mass differs according to the velocity of the observer measuring it. Its quantitative value does not change by way of inelastic interaction with other mass, but it does change if there is a change in velocity of the observer measuring it. If the relative motion between the mass and the observer increases, for instance, as by some other action such as from

fuel that is separate from the action in question of the relative mass, then the quantitative value of the relative mass is perceived to increase as well. Therefore, in one way total mass is conserved, but in another way it is not conserved.

Say an inelastic collision occurs between two masses whereby they become internally the same as they were in relative motion. The law of conservation of energy comes into play. For, if collisions were inelastic in nature, then all motion would tend to cease. For motion to continue, some other form of energy must be involved in the process of collision. As with inelastic collision, the energy could be stored internally as heat or molecular motion. As with elastic collision, internal energy is immediately used to restore the relative motion of the masses in collision. For the collision to remain inelastic and for the masses to stay internally the same as they were in relative motion, the internal energy is surrendered to whatever system causes the collision to be inelastic.

Heat is viewed as internal motion of mass, as the random motion of molecules within it, but conservation of relative mass and momentum should apply to molecular motion as well. The molecules are not able to directly surrender their motion to molecules of another system if the two systems are separated by space. However, there is still the possibility to consider of heat being absorbed and emitted as radiant energy, or light.

Masses thus exchange energy when they collide, conserving it in the process. The kinetic energy of relative motion thus maintains in some form or another. Einstein agreed with this principle inasmuch as he went on to generalize conservation of relative mass and momentum as part of conservation of energy.

According to special relativity, mass and energy are equivalent and, in effect, the mass content of a body is only one of many possible forms of energy that are convertible from one form to another. Consider, for instance, the form of energy as light. Light incident on a body exerts pressure, as predicted by Maxwell in the middle of the 19th century, and as experimentally verified by Lebedew in 1890. Two lightweight flags of paper, for instance, can rotate a small, frictionless pole if they are tightly hung opposite each other on it such that their front sides are white for them to reflect light and their back sides are black for them to absorb the light.

Considering the relativistic nature of his kinematics, Einstein went on to equate the internal energy constitutive of the mass to the specific quantity equal to the product of mass and light speed squared. He even derived this relation in a manner independent of the theory of relativity.

The relativistic mass and energy are according to the equation

$$E = \frac{E_0}{\sqrt{1-\left(\frac{v}{c}\right)^2}} = mc^2 = \frac{m_0c^2}{\sqrt{1-\left(\frac{v}{c}\right)^2}} \tag{14}$$

The mass m_0 is the rest mass of m moving at relative velocity v and m_0c^2 is the "internal energy constitutive of the rest mass." The increase in the rest mass in relative motion by $m - m_0$ is identified as the kinetic energy of relative motion, which for speeds far below that of light approximates to the Classical-Newtonian formula of $K = ½m_0v^2$.

Einstein considered a long tube containing two spheres of mass positioned at each end. Let the two spheres be denoted as A and B such as contained inside a long tube of mass M relatively at rest. Sphere A contains an excess amount of energy E_0. When inelastic collision occurs between sphere A and the tube, it causes the tube to move at velocity v with momentum Mv. A photon of light with equal energy E_0 recoils in the opposite direction at speed c. Conservation of momentum applies such that the absolute value of E_0 is equal to the absolute value of MV. Since $E_0 = m_0c^2$

$$Mv = \frac{E_0}{c} \tag{15.1}$$

$$v = \frac{E_0}{Mc} \tag{15.2}$$

Equation (15.2) is used to substitute values.

The momentum that had been given to the tube is negated when sphere B absorbs the light and passes it on to the tube by means of an inelastic collision with the same magnitude of momentum E_0/c in the opposite direction. However, during the time t of light propagation from one sphere to the other, the tube had been displaced by the distance

$$x = vt \tag{15.3}$$

Substituting E_0/Mc of equation (15.2) for v of equation (15.3) gives

$$x = \frac{E_0 t}{Mc} \tag{15.4}$$

To restore the tube to its original position a particle of mass m_0 equal in energy to that surrendered as light by sphere B is transported at a distance d back to sphere A. With all other related activity balancing out on the transporter's return trip, the transportation of the particle causes the tube to move back the distance x to its original position.

Work occurs during the process of the tube moving the distance x. The product dm_0 of weight and distance moved defines this work energy in the conventional sense inasmuch as mass is a measure of weight. Since the particle and light are of the same energy, and since the work energy used the particle to place the light energy back into position, which also restores the original position of the tube, the two actions are mutually related, such that

$$xM = dm_0 \tag{15.5.1}$$

$$x = \frac{dm_0}{M} \tag{15.5.2}$$

Combining equations (15.4) and (15.5.2) gives

$$x = \frac{dm_0}{M} = \frac{E_0 t}{Mc} \tag{15.6}$$

The last two equalities give

$$\frac{E_0 t}{Mc} = \frac{dm_0}{M}$$

$$E_0 = \frac{Mm_0 cd}{Mt} = \frac{m_0 cd}{t} \tag{15.7}$$

However, d is the distance of light propagating from sphere A to sphere B in time t. In other words, d/t is the speed of light. Hence

$$E_0 = m_0 c^2 \tag{15.8}$$

This last equation represents the internal energy constitutive of the rest mass m_0.

Since the rest mass in relative motion relatively increases by the factor $(1 - v^2/c^2)^{-1/2}$, the mass-energy equation becomes

$$E = mc^2 = \frac{m_0 c^2}{\sqrt{1 - v^2/c^2}} \tag{14}$$

The energy constitutive of the mass is thus its internal energy plus that of its relative motion.

Conserving Light Energy

Conservation of momentum and mass-energy require them to be the same even though mass can convert to another form of energy such as light. Since light has momentum, its absorption and emission are subject to the same inelastic and elastic conditions of collision with which matter complies. To verify this compliance let unit mass $m_0 = 1$ with momentum $m_o(0) = 0$ relative to observer A absorb a photon of light of momentum $m_x c$ such that m_0 and the photon energy move along with observer C at velocity .6c relative to observer A. The total mass and momentum before and after the inelastic collision are according to the equations

$$m_x c + m_0(0) = (m_x + m_0).6c$$

$$m_x c = .6m_x c + .6m_0 c$$

$$m_x = .6m_x + .6m_0$$

$$.4m_x = .6m_0$$

$$m_x = \frac{3}{2} m_0$$

The total mass before and after the inelastic collision is therefore

$$\frac{3}{2} m_0 + m_0 = \frac{5}{2} m_0$$

The total momentum before the collision was (3/2)(1) = 3/2 units. After the collision it is (3/2 + 1)(3/5) = (5/2)(3/5) = 3/2 units. Total momentum is thereby conserved relative to observer A.

The mass and momentum relative to observer C before and after the collision is related according to relative mass and a relativistic version of the Doppler formula. The Doppler formula for a decrease in energy of light due to the observer relatively moving away from the light source is according to the formula

$$\lambda = \lambda_0 (1 - v)$$

The relativistic Doppler formula in comparison is similar to the formula for relative mass. It is

$$\lambda = \lambda_0 \frac{1 - v}{\sqrt{1 - {v^2}/{c^2}}} = \lambda_0 \left| \frac{(1 - v)^2}{1 - {v^2}/{c^2}} \right|^{1/2} = \lambda_0 \left| \frac{(1 - v)^2}{(1 - v)(1 + v)} \right|^{1/2} = \lambda_0 \left| \frac{1 - v}{1 + v} \right|^{1/2}$$

Since the total momentum relative to observer C is zero after the collision, the momentums of the photon and the mass are equal in speed but opposite in direction before the absorption occurs. The relative mass m and momentum of m_0 moving at velocity **-**.6c away from observer C are

$$m = \frac{m_0}{\sqrt{1 - (.6)^2}} = \frac{5}{4} m_0$$

$$-mv = -\left(\frac{5}{4}\right) m_0 \left(\frac{3}{5}\right) c = -\left(\frac{3}{4}\right) m_0 c$$

The photon of mass-energy m_x and momentum $m_x c$ relative to observer C moving more away from the source of emission than observer A does is by the Doppler formula

$$m_{xx}c = m_x c \left|\frac{1 - v/c}{1 + v/c}\right|^{1/2} = \frac{3}{2} m_0 c \left|\frac{1 - .6}{1 + .6}\right|^{1/2} = \left(\frac{3}{2}\right)\left(\frac{1}{2}\right) m_0 c$$

Conservation of both mass and conservation of momentum are thus both verified in view of observer C as well as in view of observer A.

To verify them in view of elastic collision, as with the same mass emitting the photon in the opposite direction in which it was absorbed, the mass $(5/4)m_0$ acquires a velocity of .6c relative to observer C, as with the same speed and direction caused by the absorption of the photon. However, the velocity relative to observer A is according to the addition of velocities formula

$$v_{12} = \frac{2v}{1 + v^2/c^2} = \frac{2(.6)}{1 + .36} = \frac{15}{17} c$$

The mass relative to observer A becomes

$$m_2 = \frac{m_0}{\sqrt{1 - \left(15/17\right)^2}} = \frac{17}{8} m_0$$

The numerical units of momentum relative to observer A are thus

$$\left(\frac{17}{8}\right)\left(\frac{15}{17}\right) = \frac{15}{8}$$

The mass and numerical units of momentum of the photon is calculated according to the Doppler formula in relation to observer A moving away from the photon source (mass m_2)

$$m_{xb} = m_{xc}\left|\frac{1 - v_{12}}{1 + v_{12}}\right|^{1/2} = \frac{3}{2}\left|\frac{1 - {}^{15}/_{17}}{1 + {}^{15}/_{17}}\right|^{1/2} = \left(\frac{3}{2}\right)\left(\frac{1}{4}\right) = \frac{3}{8}$$

The total units of mass relative to observer A therefore remains as

$$\frac{17}{8} + \frac{3}{8} = \frac{20}{8} = \frac{5}{2}$$

The total units of momentum relative to observer A remain as

$$\left(\frac{17}{8}\right)\left(\frac{15}{17}\right) - \left(\frac{3}{8}\right)(1) = \frac{15}{8} - \frac{3}{8} = \frac{12}{8} = \frac{3}{2}$$

Relative mass and momentum are therefore conserved by way of a free moving particle of mass absorbing and emitting a photon such that the relative masses of the photon and the particle comply with the formula comparing the mass in relative motion with the same mass relatively at rest.

In showing that relative mass is conserved in inelastic collision it was assumed that the masses merely collide and stick together. However, if the collision between masses were ultimately inelastic in nature, then all of mass-energy would tend to coalesce as one inert mass. There thus exists a more complex process at work that allows inelastic collision to occur. Now that it is also shown that a particle can increase or decrease in relative mass by way of an exchange of energy with the light it reflects, or absorbs and emits, it should now be realized that two masses colliding stay together as one combined rest mass by surrendering energy as heat to other mass or simply radiates energy into space.

Particles of mass combining and decomposing as such are typical of quantum physics. They should also be typical of the stress conditions of space-time curvature that give rise to the gravitational effect according to general relativity theory.

Space-Time Curvature

Special relativity theory was founded on constant light speed and covariance. General relativity theory is generally covariant with regard to gravity and one more postulate: the principle of equivalence whereby gravitational mass and inertial mass are equally the same. A change in momentum of a mass is thus the same whether caused by either gravity or a collision with another mass at the same relative speed per second that the momentum changes at by way of gravity. Isaac Newton was reluctant to make this connection, as he left open the possibility that his inverse-square-law for gravity might not be universal everywhere in the universe. He assumed it was valid only locally. Experiment nonetheless confirms the equivalence of inertial and gravitational mass to at least one part in 10^{13}.

Some philosophers had argued against the equality of inertial and gravitational mass. Ernst Mach, in particular, argued that the inertia of a particular mass depends on the relative distribution of all other mass in the universe. General relativity theory actually explains Mach's principle by way of general covariance such that the principle of equivalence holds true.

Consider the gravity of matter as an anomalous condition of the space-time continuum. That is to say that there would be no gravity if all mass were distributed evenly throughout all of space. For instance, there is zero gravity at Earth's center of mass, which includes the influence of all other mass in the universe as well. Gravity thus occurs because of an uneven distribution of mass. By the condition of general covariance this uneven distribution of mass has the same exact effect no matter where it occurs.

Another interpretation of the principle of equivalence, as given by Einstein, is that an observer in free fall experiences no internal effect of gravity, as in being inside an enclosure falling freely to Earth. An opposite effect is an observer on Earth's surface who is not in free fall experiences the acceleration of gravity as weight. However, there are tidal effects to consider. Ocean tides, for instance, result from the gravitational influence on the part of Earth the moon is closes to.

Einstein's general field equations are thus more complex in their description of nature. His tensor calculus involves various conditions of

stress, density, pressure, momentum and so forth. In order to relate to his interpretation of the principle of equivalence above, solutions to his general field equations usually assume simplified conditions of nature. At an infinitesimal volume of space-time curvature, for instance, tidal effects of gravity are minute for space-time conditions of special relativity theory to apply.

Although Einstein's tensor calculus is complex, it is only a means of notation for a complex array of effects. The laws of physics still apply according to the basic principles of theory. In plain English, conservation of relative mass-energy and momentum hold true for the complexity of space-time curvature in similar manner that they do for the conditions of special relativity theory in gravitational free space.

Conditions of special relativity theory apply with regard to free fall equating as inertial motion. There is thus no difference between free fall and inertial motion to be aware of by an observer following the free path of space-time curvature. All effects are comparably the same. This means also that systems not in free fall experience the opposite effect. They are in a state of acceleration. The surface mass of Earth, for instance, pushes against Earth to accelerate outward. In so doing it creates pressure inside Earth that results in heat energy. Some of it is radiated into space.

What is at issue is how conservations of relative-mass energy and momentum apply. Earth's surface pushes inward in accelerating outward. As it does, it sometimes collides with mass-energy and light. The longer is the fall the greater is the energy of collision. As with matter in free fall an increase in kinetic energy of relative motion occurs, whereas with light in free fall the increase in energy occurs is regard to a Doppler shift towards the more energetic, blue end of the light spectrum.

Are the resulting conditions inelastic or elastic in nature?

Kinetic energy is defined by the theory of special relativity as the difference between relative mass and rest mass. As with regard to either elastic or inelastic collision there is neither an increase nor a decrease in mass-energy. By way of elastic collision relative mass is exchanged from one mass to another. By way of inelastic collision relative mass is retained internally to be released as some other form of energy. As with regard to free fall there is an increase in energy before the collision occurs. There is

therefore, contrary to Einstein's unique interpretation of the principle of equivalence, an action taking place in free fall before the collision occurs.

There is no internal awareness of a change in energy from free fall by observers in the same state of free fall. However, observers apart from free fall do detect the change in relative motion of a mass in free fall. For conservation of mass-energy to apply with respect to them there must be an exchange of energy taking place with space-time and the mass-energy in it.

This exchange of energy with the space-time continuum appears more evident with respect to observers apart from the field, as relatively at rest in gravitational free space. To them the conditions of the field are further complicated by light speed and relative motion in proportion to it being slower in the field.

This gravitational retardation is derivable from a particular metric as a solution of Einstein's field equations: the Schwartzschild metric. It is of the form

$$ds^2 = \left(1 - \frac{2GM}{r}\right) dt^2 - \left(1 - \frac{2GM}{r}\right)^{-1} dr^2 - r^2 d\theta^2 - (sin^2\,\theta) d\varphi^2 \qquad (15)$$

The infinitesimal interval ds is with regard to the simultaneity of events in view of constant light speed, where dt and dr are increments of time and distance where the gravitational field of mass M is homogeneous within an infinitesimal volume of space for special relativity theory conditions to apply. Since conditions are relatively homogeneous, space-time curvature also compares in form of Newton's gravitational potential, $GM/r = v^2$, G being the gravitational constant and the escape velocity at r is the square root of 2GM/r. The escape velocity determines the gravitational strength of the field and replaces v for relative motion. Light speed c is defined as unity such that it does not visibly appear in ratio to the escape velocity. The polar coordinates $r^2 d\theta^2$ and $(\sin^2 \theta)\, d\varphi$ are similar to perpendicular coordinates of relative motion and are omitted if inconsequential to the event in question.

If the event in question refers to light particle, then the difference between the displacement of a particle (a photon) and its observation is zero. Hence ds =0. By omitting polar the coordinates from equation (15) it becomes

$$0 = \left(1 - \frac{2GM}{r}\right) dt^2 - \frac{dr^2}{1 - \frac{2GM}{r}}$$

$$\frac{dr^2}{1 - \frac{2GM}{r}} = \left(1 - \frac{2GM}{r}\right) dt^2$$

$$\frac{dr^2}{dt^2} = \left(1 - \frac{2GM}{r}\right)^2$$

$$\frac{dr}{dt} = 1 - \frac{2GM}{r}$$

The relative speed of light in a gravitational field is thus less than unity.

Significantly, 2GM is zero in the absence of a gravitational field. The numerical value of dr/dt is thus the number one, which, in this case, is light speed in gravitational free space as one unit of distance divided by one unit of time.

Relative motion is thus relatively slow in a gravitational field. The moon's orbital motion around Earth, which is representative of a natural clock, is relatively slow. However, since clocks are retarded by the same relativistic factor, both light and relative motion in the field are the same to an observer in the field as if they were in gravitational free space.

Observers in gravitational free space outside the field perceive the event in the field differently, but the interpretation of their perceptions is arbitrary. They can determine whether light in the field is relatively slow or space-time in the field is relatively extended.

Maintaining the constant nature of light speed is consistent with special relativity theory, but there are further consequences with regard to conservation of relative mass-energy. If space-time relatively expands in the field, then orbital distances are relatively extended whereas orbital velocities remain the same. Since orbital velocity decreases in proportion to its distance from the center of mass and increases in proportion to the mass, an increase in mass-energy compensates for an increase in orbital radius for maintaining the same orbital velocity.

Since the whole field expands the gravitational potential does not increase outside the field, but the internal increase in gravitational mass-energy is in violation of conservation of energy unless there is a source of energy somewhere in the field to account for it.

To be consistent with the condition of inelastic collision the total mass need not change, as the mass already contained in the gravitational field and one falling freely into it. By interpreting the speed of light in the field as actually slower there is no increase in the gravitating mass. There is, however, an increase in kinetic energy of free fall that still is not here explained.

The decrease in light speed indicates that space-time does indeed contain a source of energy to exchange with mass and light in free fall. It is therefore part of the equation. Space-time somehow exchanges mass-energy with light and matter in the manner of maintaining conservation of mass-energy.

The Gravitational Effect

In explaining conservation of mass-energy it was assumed masses in inelastic collision do not surrender their relative mass. It is exchanged by way of the reverse process of elastic collision. However, this process is only illustrative for conservation of mass, assuming that the masses exist as isolated systems apart from the space-time continuum, but the mass-energy of inelastic collision of isolated systems needs to be contained in a manner consistent with the nature of energy.

As with relative motion, inelastic collision can result from masses containing energy as internal motion, as heat, which could be emitted as radiation for them to restore their original states of rest mass while they stay together. As with gravity, the conglomeration of mass is achieved by exchanging energy with space-time according to the total distribution of all mass that determines its relative state of curvature.

Space is full of such energies as neutrinos that pass through Earth nearly undetected except for only a minute number of them interacting with Earth's matter. In view of their invisibility their energies could be in a dynamic state of equilibrium in which mass-energy is an equilibrium state anomalous to others. Within this equilibrium state is the opposite flow of

two different energies maintaining the presence of matter. One energy flow interacting with matter is inward; the other is outward. Light energy and matter tend to respond slightly more to the inward flow of energy, thus producing the gravitational effect.

Say the smooth distribution of universal energy includes quantum states. As long as these quantum states are themselves evenly distributed there is no gravity to reckon with. Let this quantum state of existence be called plasmatic in nature. It is the energy that holds matter together and combines with matter to produce the gravitational effect.

Matter and plasma coexist as various equilibrium states whereby gravitationally free plasma allows freedom of movement in the relative space-time continuum that surrounds matter. As for the containment of matter within these equilibrium states, a denser and more inert state of plasma is required.

Plasma and matter both interact with light, reflecting or absorbing and emitting it. The plasma is also a medium for light propagation. Even though the plasma closer to matter is more inert, the propagation of light through it tends to divide it. As particles of matter constantly exchange a particular quantum of light energy that propagates through the plasma, it becomes relatively less dense between two particles of matter. There is a plasmatic push towards the center of mass for a new equilibrium state. A gravitational effect thus occurs.

Questions and answers:

- How does matter move freely through the plasma?

If space-time is a plenum, then there is no wiggle room for non-rotational wave-like action to occur. If there is vacuum space, then there needs to be a way for mass to bond together for the existence of particle-like action. Light having and maintaining the same speed in empty space suggests a medium of some sort, but conventional wave theory of three-dimensional media describes waves as spreading apart to disperse energy as they move away from their source of disturbance. This action in a non-material medium would violate conservation of momentum in each initial direction of motion. If a medium in space does exist the wave nature of the energy propagating through it must therefore be particle-like.

If matter is primarily wave-like in nature, it can simply propagate through a medium as quantum waves of energies. However, because its nature is distinctly different from that of light, it is a combination of part quantum wave action and part medium for other quantum waves. They thus interact. In effect, they reflect or absorb and emit other parts of the media for a variety of particles to exist and propel themselves through it.

As a medium, some energy simply propagates through it whereas, as a particle, it reflects energy to maintain form as existing in a particular state of equilibrium with the medium. Whatever it reflects depends on its equilibrium state, which is altered by its interaction with light and other material particles. Part of its new energy state is determined with regard to relative motion and gravity. It thus does not reflect the same energies from all directions in one state of relative motion that it does in another state of relative motion. Its adjustment to its environment thus allows it to propel through space.

The explanation of gravity is similar but more complex. As matter is in static equilibrium with the surrounding plasma that helps contain it, it converts plasmatic energy into a form that is less detectable by matter. Other plasma or matter moves in to fill the void. The proportion of mass to plasma is constant, as more mass requires more plasma to contain it, but more mass also converts more plasma to a more undetectable form of energy.

The process is a recycling one, as the plasma reabsorbs the energy at a slower rate than its conversion by matter. The conversion from one form to the other and back depends on the homogeneous distribution of mass such that the relative plasmatic density filling the space around and between mass is according to the conditions of space-time curvature that approximate to Newton's inverse-square-law for distance.

- What is a graviton?

A graviton propagates the gravitational effect at the speed of light in order to comply with the condition of special relativity theory that no information of an event can be propagated faster than light speed. Since it moves at light speed it has no rest mass, as neither does light, but it is a different animal. Whereas light has momentum that converts from pure energy into mass-energy, the graviton is only a messenger particle. As the

relative positions and densities of matter change, new equilibrium states take time to form. This adjustment propagates outward from each new position of mass at light speed.

If to the contrary gravitons maintain negative momentum, as to gravitate mass, then the change in momentum of a mass somehow needs to be compensated for in the opposite direction. For instance, apart from the atmosphere, a rock and a feather fall to Earth at the same rate. Since the mass density of the rock differs from the mass density of the feather, the changes in momentums of the rock and the feather differ.

How a single graviton can perform this task as a contiguous action through space is incomprehensible in view of the laws of physics. Since it is still needed to communicate the gravitational effect, it is thus retained as an indicator of a more complex process at work.

- How does all mass fall at the same rate?

With mass in a state of equilibrium with plasma, unequal masses could fall at the same rate if a pure vacuum state was equally created for them to fall towards. Twice the push on twice the mass is proportionally the same on each part of the mass. However, the interaction of mass and plasma does not create a pure vacuum state. A momentary vacuum is left in the wake of plasma released as another form of energy, but the energy released is in proportion to plasmatic interaction with mass. This vacuum is filled by the same amount of energy that plasma vacated.

Therefore the vacuum state in itself is also inadequate to explain the gravitational effect. The process at work is still more complex.

All interaction between plasma and matter readjusts to each new state of equilibrium. The interaction is by way of photonic energy. Matter and plasma both scatter it by reflecting or absorbing and emitting it in all directions. More matter and plasma scatter more of it such that twice as much matter equals twice as much scattering of photonic energy. It is this quantum nature of energy maintaining balance between plasma, matter and photonic energy that results in matter and plasma falling at the same rate.

- How does photonic energy cause gravity or space-time curvature?

The direction of scattering photonic energy by matter and plasma is uneven. When matter gravitates towards other matter it scatters more photonic energy in the opposite direction in maintaining conservation of momentum.

This uneven scattering is due to a relatively denser plasmatic state nearer to matter. Furthermore, the amount of plasma is proportional to the amount of mass. The denser plasma is more difficult to plow through. Motion through it is thus relatively slower. To compensate for this slower relative motion through it more photonic energy is reflected and emitted away from it.

The plasma also converts to photonic energy, thus keeping up the supply, but the converted plasma is replaced by more inert plasma that gradually absorbs photonic energy depending on the relative distribution of mass such that it pushes forward to the center of mass.

Momentum in view of the gravitational effect is thus conserved in the manner of special relativity theory, as the contiguous action between light and matter, light and plasma, and plasma and matter in manner of a recycling process.