A Mystic History In Light Of Physics

Bob Ticer

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DEDICATION

This work is dedicated to all the natural philosophers whose efforts have led the way to our understanding of the natural world. Whatever this book provides for our understanding, it is only a tiny part of its continuation that will undoubted be exceeded by more efforts of the present and future.

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PREFACE

When Shayla stepped off the school bus she laid down on the sidewalk beside the neighbor kid. He was doing her homework.

I had to convince Shayla that you learn by doing and that she was not learning by letting someone else do her homework.

As for the reason she did not do her homework, it was because she had developed a mental block with math. I told her math was a small step by step process and that taking each small step would lead to success, but that getting behind would result in a mental block.

She did not understand how to subtract 60 from 80, but she knew how to subtract 6 from 8. I informed her she did not need to memorize each equation, as only ten essential numbers need be added, subtracted, divided and multiplied. For instance, subtracting 60 from 80 is nothing more than subtracting 6 from 8 and 0 from 0 to get 20 as 2 tens.

The mental block had already taken effect. When I offered her a small calculator to help her learn math, it became apparent that she was confused as to which way to read numbers. For instance, she would read 56 as 65. She did not have dyslexia, at least as of yet; she had developed instead an inferiority complex in believing that she was expected to know everything grownups know. I told her it is difficult to learn anything if you already know everything, as life is a learning process even for us grownups. I also pointed out to her that she did learn, as when she correctly answered 11 plus 4 as 15. The praise was to encourage her not to give up in the face of defeat, but to confidently know she can find the necessary steps to learn. Mistakes can unfortunately be fatal, but I ensured her that those of us who learn from them are more likely to achieve success.

Life is also a learning process for us all, as evident with the historical evolution of theoretical knowledge. However, although scientific theory evolves as a step by step process, a complete knowledge of these steps is generally missing for most of us. An understanding of the tensor calculus of general relativity theory, for instance, is a complex undertaking that only a few of us are willing to commit to. As a result, most of us are inclined to either accept or deny a theory according to faith.

Some of us are more faithful than others. Some of us prefer instead a rationally complete understanding of the world in which we live. Generally we are stuck somewhere between faith and understanding, but the internet now promotes experts on any subject to more easily contribute to a world wide web of knowledge.

Physicists have claimed a supercomputer is needed to solve Einstein's general field equations, but computer programming is based on the binary code, as only a two number system. It is thus possible to relate Einstein's general field equations to a step by step process for it to be more easily comprehended, but the steps in this case are too numerous enough to fill volumes of books.

The math allows us to accurately describe specific aspects of nature. The math complexity also simplifies the task for experts in the field, but it is not needed for a fundamental understanding of theory.

The fundamental understanding of theory can also be undertaken in accordance with its history as a step by step progression that provides for a convenient reference to which everyone can relate. However, the history of physics has a mystical side to it. In view of Aristotelian physics, for instance, this mystical element included light as the means from which the divine source of all creation supplied the material world with motion and energy. Nowadays, the relativity of space and time, and of mass and energy, is now described according to how light interacts with matter. Moreover, the whole universe is now assumed to be finite whereby all of its enormous matter and energy expanded, and still expands, from a singularity, a space so tiny that it cannot be defined. Included in this theory are the concepts of dark matter, dark energy, black holes, worm holes, many more dimensions, other universes and so forth.

The expanding universe cosmology struggled for a decade or more to become accepted by the majority of mainstream physicists. This difficulty of acceptance is typical of most new theories attempting to overcome the dogmatic view of the establishment. Copernicus, for instance, struggled to establish the heliocentric theory of Earth and the other planets in the solar system, as the Aristotelian doctrine of Earth at rest in the center of the universe had become the official position of the Catholic Church for its interpretation of reality.

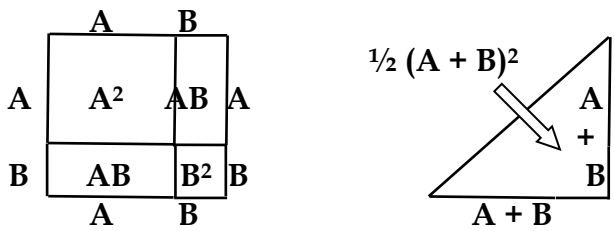
The big bang theory of an expanding universe is now established, but the establishment has been challenged and revolutionized for centuries by new theories for their abilities to better explain new discoveries. It also is questionable whether big bang theory will remain in the distant future as established as it is now. It does have a determined challenge of an electric universe theory and a tired light one explaining the cause of light distortion as due to its encounter with the existence of a plasmatic state of matter in intergalactic space instead of as due to an expansion between galaxies.

The electric universe and expanding universe are both theories with historical origins. Even though the expanding universe theory is now the more popular of the two, in time it could possibly be superseded by the other one. As to whether such speculation of dark energy and worm holes

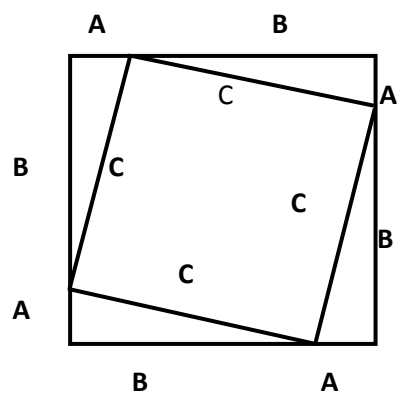
are retained as part of an all embracing new theory, or they are eventually disregarded as having a mystical outlook, it could very well depend on a general step by step interpretation of the history of theory.

A complete understanding of all this seems out of reach for the simple minded, but Einstein suggested a simpler understanding of relativity theory is possible in view of the Pythagorean Theorem: ($C^2 = A^2 + B^2$). An effort has thus been made to simplify all the mathematics in this book for it not to be any more difficult to understand than is the Pythagorean Theorem.

For $(A + B)^2 = A^2 + 2AB + B^2$, as in direct relation to arithmetic, let A = 2 and B = 3 such that (A + B)(A + B) = (2 x 2 = 4) + (3 x 3 = 9) + (2 x 3 = 6) + (3 x 2 = 6) = 25 = (2 + 3) x (2 +3) = 5 x 5 = 25.



$$(A + B)^2 - 4\left(\frac{1}{2}AB\right) = C^2$$
$$A^2 + 2AB + B^2 - 2AB = C^2$$
$$A^2 + B^2 = C^2$$



INTRODUCTION

Rene Descartes philosophized, "I think, therefore I am. If I am deceived of my existence, then I must at least be the Deceiver." He therefore confirmed his existence by way of his own awareness of himself.

Am I alone?

Resistance to thought and action testifies there is an objective world extending beyond my control. I am not alone. We therefore exist.

I witness existence, but I do not seem to know how either existence or a state of consciousness is possible. I therefore merely assume we are parts of creation, as by either a Supreme Being or from what already exist.

Can something exist without our awareness of it? No matter. Never mind. The mind-matter duality is of no concern, as this book is about the physical world inasmuch as material existence is comprised of a substance of some sort that varies in shape, size, density and so forth. In this regard, philosophers have attempted to explain everything existing in the physical world as part of a primary substance that became referred to as æther.

Suppose all physical reality is indeed comprised of æther. What, then, are its properties? How does it, for instance, separate from and recombine with itself in creating all the effects of reality? A substance being primary implies it has no internal mechanism to bond to itself other than by pushing against other primary substance. It must thus be intrinsically elastic in order to maintain a force of action by way of motion, as all action between itself would otherwise result in a loss of relative motion.

Another likely condition for primary substance is that it needs to be of infinite content, even to partially fill infinite space if not all of it, in order for it to be able to change direction by way of elastic collision instead of spreading apart without a means to reverse direction to again interact with itself. The question then comes to mind as to whether space is a plenum of æther or a partial vacuum and æther.

Descartes, along with other philosophers, assumed space consists of a plenum.

How, then, do various densities of matter exist if æther is everywhere identical in composition?

A plenum does not even have wiggle room for a wave action to occur in the manner sound propagates as compressed states of air molecules. The æther as a plenum is thus contrary to the air medium for sound.

It is no wonder that early Greeks deep in thought regarded our world as illusionary. As for the plenum, they considered circular motion in it as possible. Motion is allowed by the complexity of circular paths.

Descartes also assumed all stuff moves circularly. He described it as evolving into a complex system of vortices of various sizes and rotational speeds. Total motion is conserved, as allowed by the movement of other æther. As for the complexity of motion, endless possibilities exist by way of vortices moving inside other vortices in creating various relationships. A number of like vortices in one region of space can thus be relatively denser than those in another region of space. However, since the density of this primary substance is everywhere the same, our world comes about primarily by an exchange of motion between vortices.

The source of all creation is thus already created out of what already exists ad infinitum.

In Light of Physics

Some things seem unexplainable; other things can be explained even if they seem improvable. We cannot, for instance, explain the existence of the æther if there is indeed this primary substance from which all things form, but we can use it for explaining constant light speed. A mathematical explanation of it, in fact, was given at the turn of the late 19th century by Hendrik Antoon Lorentz. His equations indicate there is a cancellation of effects whereby the absolute state of rest through which the æther moves is invisible to us.

As an alternative to explaining the null results of experiment, Albert Einstein postulated the constant nature of light speed as an experimental fact, as to make no reference to the æther. He stated the concept of the æther is not necessary to formulate theory; all that is needed for describing the observable world in its functional manner is to formulate laws of nature mathematically.

Einstein formulated special relativity theory (SRT) as a self consistent theory in agreement with observation, but physicists were still speculating on the true natures of light and matter. Max Planck had proposed in 1900 a quantum condition for explaining particular effects of thermal radiation. In support of this quantum condition, Einstein explained the photoelectric effect as particles of electrons recoiling from the impacts of particle-like radiation instead of wave-like properties, as had previously been discovered of light.

Leading into the twentieth century was these two revolutionary ideas with regard to the relativistic and quantum nature of light. For the most part they were not at odds with each other. For instance, a similar effect to the photoelectric one is the Compton Effect whereby Compton formulated quantum effects in a manner consistent with relativity theory. Similarly, in 1924, Louis de Broglie discovered wave-like properties of matter, which he formulated quantitatively according to relativity theory.

Initially the quantum was nothing more than an added condition of relativity theory, but it developed as a contrary means of explaining nature. Whereas relativity theory is deterministic with regard to cause and effect, quantum mechanics interprets the quantum as conditional to probability.

This condition of probability pertains to the wave effects of nature. Erwin Schrodinger provided a wave equation to formulate de Broglie's ideas according to Wave Mechanics whereby an electron cloud produces quantum effects. However, subsequent analyses of the particle-wave duality by such physicists as Bohr, Born and Heisenberg led to the principle of uncertainty, as stated by Heisenberg. The world on the atomic scale is thus indeterminate with regard to direct cause and effect.

In 1927, top physicists of the time convened in Copenhagen, Germany in concluding a yearlong debate ending with the Copenhagen Doctrine. As it were, Schrodinger's wave equations had been shown to be successful for predicting events, but the leading physicists Max Born, Werner Heisenberg and Niels Bohr argued there is an impossibility aspect of determining exact position and exact momentum of a particle, as the means of observing them (as by light) necessarily influences the outcome of the event. Schrodinger's wave equations were thus accepted as a means of predicting outcomes, but they were also reinterpreted as probability equations.

Along with indeterminism and particle-wave duality was the demise of the æther as a valid means of explaining nature. Since the primary aim of science is to describe nature according to observation, and since experiment indicates the æther is invisible if it does exist, it is thus non-existent as far as science is concerned.

Although Einstein stated the æther is superfluous for the formulation of theory, he did suggest that it is useful for understanding theory by way of a historical perspective. There are, for instance, experiments attempting to determine the simultaneity of events, as contrary to relativity theory, but interpretations of their results could also be misleading if they are without historical reference to the invisible æther as a state of motion designated as at absolute rest. If the simultaneity of events is absolute instead of relative, for instance, it is then possible to determine the speed of light with respect to absolute rest, which is what really needs to be proven. Premature claims

contrary to the history of relativity theory therefore tend to confuse rather than benefit our understanding of it.

Although Einstein was highly respected for his opinion, his suggestion was trumped by the other leading physicists of the time. They decreed the æther is beyond objective science. Since the æther is determined as invisible at best, it is thereby proven not to exist as part of the observable world.

Criteria of Theory

A theory of science is generally valued by how it describes, explains and predicts events of the natural world. Thermodynamics, for instance, describes heat as the random motion of molecules within matter. It explains the cooling effect of our bodies from a fan as due to our warmer bodies transferring more heat to cooler air blown on our bodies by the fan. It predicts that the fan will warm our bodies if the temperature of the air exceeds that of our bodies. Air can be cooled by first compressing it, as to condense its heat to a higher temperature than its surroundings that thereby absorb it, and then to allow the air to expand to a lower temperature than before.

If a theory does not predict anything, it is of no use to science. The ability to predict results is thus what establishes theory. General relativity theory (GRT), for instance, became established after its prediction that the path of light close to a massive body, such as the sun, is curved was confirmed by astronomers.

Another establishment according to prediction is the big bang theory. It became established from a discovery of a cosmic microwave background radiation (CMBR) whose temperature at present agrees with theory in that constant expansion of the universe from creation has cooled it. The original prediction was five degrees Kelvin by Ralf Asher Alpher (1921-2007), as in accordance with his explanation of how heavier elements formed from the cooling of the universe from its expansion. At the time, however, an exact rate of the expansion was not accurately known, which lead to such other predictions of the CMBR as 50 degrees Kelvin by Gamow and 10 degrees Kelvin by Peebles. It was eventually determined as 2.7 degrees Kelvin even though the range in value of the Hubble Constant has varied over the years from about 50 to 80 kilometers per second for the distance of one million parsecs. Some physics historians also point out that a book authored by A. Eddington in 1926 predicted a CMBR of 3.2° K according to the Stephen-Boltzmann 4th power law applied to a state of cosmic equilibrium of infinite size. In 1933, Erich Regener (1881-1955) calculated it as 2.8° K.

Olaf Kristian Bernhard Birkeland (1867-1917) also proposed a theory as early as 1896 that did not receive acceptance until confirmed by a space probe in 1967. After providing a general solution to the equations of the

theory of electromagnetism, which was formulated by James Clerk Maxwell (1831-1879), Birkeland applied the theory to explain the auroras of northern and southern lights as disturbances from the sun's radiant energy interfering with the magnetic field above Earth's atmosphere. Because he described the magnetic field as an ionized gas, and since Lord Kelvin had stated all space and above Earth's atmosphere is void of matter except for the sun, planets and such other distant objects as comets and meteorites, Birkeland's theory was discarded until a magnetic field of plasma was discovered by a military probe in 1967. An overwhelming amount of evidence in support of it in the 1970s occurred by way of satellites in orbit. It is now estimated that more than 99 percent of mass in the universe is in the ionized state now called plasma.

Consistency of Theory

History is not only useful for an understanding of theory; it can help maintain and restore consistency of theory. As a theory evolves, it adapts to explain phenomena. Sometimes inconsistency results because of incorrectly adapting to new discoveries. Sometimes further correction of past theory is needed. The big bang theory, for instance, is a prime example of theoretical evolution. It has been modified repeatedly in order for it to be consistent with new discoveries, and it most likely will require further modification if not replaced with a new theory altogether.

The big bang theory has been challenged with internal inconsistencies, as with problems regarding flatness, fine-tuning, a monopole, the nature of a horizon, etc. Alan Guth resolved most of them with a concept of inflation predicting lumpiness during early expansion, but this success is countered with another problem.

The other problem is that the expansion rate appears to have increased instead of decreased by gravity. The existence of dark energy is assumed its cause, as by the cosmological constant provided by Einstein's general field equations. The cosmological constant is a natural result of the calculus, but any value, including zero, is possible. It is thus allowed but not required, and there is counter reason that it does not apply.

One reason why the cosmological constant might not apply could be a Cosmic Coincidence that the big bang theory does not explain, at least as of yet. Gravity, as indicated by the equation below, is an extremely weak force compared to an electromagnetic one

$$\frac{Gm_p m_e}{e^2} = 4.4 \times 10^{-40}$$

G is the gravitational constant of proportionality that helps determines the gravitational potential or force at any distance r from mass m in the manner

Gm/r. In contrast, e is an electronic unit of charge relating electromagnetic potential in the manner e^2/mr. The above equation is obtained by dividing a gravitational potential of the proton mass m_p by the electrostatic potential of the electron mass m_e, with both being at the same distance apart from each other.

A numerical equivalence to this ratio occurs in relation to the Hubble Constant H_0. Its value according to data obtained by a deep space probe (WMAP) is $H_0 = 70.5 \pm 1.5$ kilometers per second from a light source one million parsecs away from us. At a distance of $2r_n = 5.76 \times 10^{-12}$ centimeters, which is the diameter of the nucleus of the hydrogen atom, the velocity of the Hubble Constant is much smaller. Since a million parsecs is 3.09×10^{19} kilometers, dividing 70.9 kilometers per second by 3.09×10^{19} km, and then multiplying the result by 5.76×10^{-12} cm, is 1.32×10^{-29} cm per second. This velocity per light speed of 3×10^{10} cm per second also has the numerical value of 4.4×10^{-40}. Because 70.9 km per second is well within the range of 70.5 ± 1.5 km per second, the relation below is suggested

$$\frac{H_0(2r_n)}{c} \cong \frac{Gm_p m_e}{e^2}$$

The speed of the Hubble Constant at a distance equal to the diameter of the hydrogen nucleus thus appears equal to the ratio of electromagnetic and gravitational potentials between the proton and electron masses.

Big bang cosmology provides no explanation, as of yet, for the Cosmic Coincidence. The reason for this lack of explanation is the constant rate of expansion is actually variable. If the universe expands, the rate of expansion is constant with distance, but it is not constant in time. It decreases by the increasing distance between galaxies. The Cosmic Coincidence, in theory, is thus just a coincidence.

A remarkable coincidence it is, and it is one that might be explained by either modification of big bang theory or by some other theory. There is no lack of candidates, which include the electric universe of plasma cosmology, a new tired light theory, and an application of Zero Point Energy (ZPE).

Another asset of history is discarded ideas due to lack of development even though they might someday turn out to be true. Birkeland's plasma is one example; ZPE might be another.

Plank had pioneered the concept of ZPE as an attempt to explain the quantum according to classical laws of nature. It means that if you remove all mass and heat energy from a system, there remains energy of motion in space. It was pioneered by Plank in 1811 before Heisenberg proposed his uncertainty principle. ZPE is consistent with this principle, which predicts events occur exactly according to the probability conditions of a virtual field

of particles. There is thus a condition of probability that motion must exist at a temperature of absolute zero.

Another requirement of theory is that it needs to be consistent with other theory. Einstein, for instance, attempted for several years to unify his field theory of gravity with that of electromagnetism. Here, too, ZPE and plasma cosmology could be relevant. Plasma is of an electrical origin, and ZPE might help explain both quantum and relativity aspects of reality.

Big bang theory requires an underlying source of energy to explain an increase in the rate of expansion. ZPE might very well be this mysterious energy, which is now referred to as dark energy. However, this assumption implies big bang theory is indeed correct.

Another possibility is a New Tired Light Theory proposed by Lyndon Ashmore. It explains the Hubble Constant not as a redshift due to galactic recession; it is instead a redshift caused by the absorption of light energy as it moves through the plasma in intergalactic space. Some evidence in favor of it is the discoveries by Tift and other astronomers that there appears to be a redshift in correlation with the plasmatic density of galaxies and their clustering.

The Objective

A means to understand is to challenge what is not understood. It is not the purpose of the challenge to prove a theory wrong. The objective of this book, for instance, is mainly to review history of physics for a more simple understanding of its development. The history here considered reaches far back as Aristotelian physics, and it includes quantum physics, relativity and cosmology in view of the æther. The difference from established theory by this approach is mainly with regard to its methodological use of the æther for the simpler understanding of theory. As with regard to the results, there is a slightly different interpretation of a "Schwartzschild singularity" and the Hubble Constant, but they are explained in consistent manner with the laws of established physics.

Although the æther is now regarded scientifically invalid, it is here used for an understanding of theory. The æther not only provides the means to explain the nature of the constant speed of light; an explanation of how it is possible that matter can emit gravitational energy in a way it continues on gravitating all mass the same and not violate conservation of momentum is provided as well. However, although the nature of gravity is understandable by means of the æther, its explanation is consistent with established laws of physics. The equivalence of inertial and gravitational mass, for instance, is a founding principle of general relativity whereby conservation of momentum and conservation of energy apply equally according to either relative motion or gravity. However, questions remain, as to how it is possible gravitational

energy from its continuous creation does not overfill space. An explanation is provided with regard to tired light and the Hubble Constant insofar as it allows for a recycling of gravitational radiation back into mass-energy.

Explanations of all these effects are in accordance with a plenum, and they are consistent with a tired light theory and a recycling universe that is without limit except for being divided into finite parts limiting observation to within a particular one.

Further significance of the consistency of all these explanations is that they pave the way for a unified field theory with regard to gravity of general relativity theory (GRT) and the virtual field of quantum electrodynamics (QED), as according to mathematics of quantum probability indicating any observable universe, as part of a multiverse, could be either expanding or static, as consistent with both the big bang and tired light theories.

Although QED is interpreted according to a condition of probability, it does not actually contradict relativity theory, which essentially constitutes a geometrical description of physical events according to the relativity of space and time. As long as the probabilities are covariant, as determined the same for all inertial systems of relative motion, then they are relative as well. QED is further consistent with GRT if the relativistic effects of gravity are analogous to those of relative motion. As such, it is here proposed gravity is a particular form of energy consistent with relative motion with regard to the equivalence of inertial and gravitational mass.

GRT interprets gravity as spacetime curvature due to the presence of mass. How does the presence of mass curve spacetime? It is here proposed that mass converts inertial energy of space into gravitational radiation to result in a vacuum effect in the wake of its emission. The consistency of this vacuum effect with the equivalence of inertial and gravitational mass is with regard to how it is emitted. It is emitted according to the Doppler principle, being greater both in the direction of relative motion and per mass.

Radiation is also quantized according to quantum physics. However, a particular quantum varies according to relative motion and gravity, and the relativity of this variance is continuous in relation to the Doppler principle, even as a quantum of gravity that is commonly referred to as a graviton. The graviton is relevant inasmuch as SRT requires no information of events can be received at a distance faster than the speed of light, as to include any change in location of the gravitational effect. Gravity thus communicates its effect from the quanta of gravitational radiation, but the gravitational effect itself is a vacuum effect in the wake of emitted radiation, as in accordance with the Doppler principle.

In being consistent with conservation of energy, a recycling process is also in order for the gravitational radiation to convert back to an original

form that produces the inertial condition of spacetime for the gravitational effect. This recycling is explained in a manner consistent with the Hubble Constant and tired light theory. However, as big bang theory is not proven incorrect, the tired light aspect of theory is only a simplified description of reality in a similar sense that the heliocentric description of the solar system is simpler than are the otherwise complex system of epicycles describing all other motion in relation to Earth being at rest.

Big bang theory does not yet explain the Cosmic Coincidence, but a possible explanation is similar to one once proposed by Dirac. He proposed the gravitational constant decreases along with the Hubble Constant as the universe expands. However, this decrease in the gravitational constant can also be interpreted in a manner consistent with relativity theory whereby the decrease is nullified by a relativistic change in spacetime. A decrease in mass density of the gravitational field allows for the relativistic expansion of mass particles in the field in nullifying the expansion of the universe according to how it is perceived. Further variables such as dark energy becoming visible are influential to the outcome.

This outcome is more complex in contrast to the aim of simplicity, but the results of big bang theory are also complex. In accordance with theory, for instance, the universe is now about 13.8 billion years old. However, if a star is 12 billion light years from us, whereby it takes light from the star 12 billion years to reach us, then the star is about (12 + 13.8) billion years old. The Hubble Constant is thus more complex insofar as different distances of stars are not the actual distances at which they are observed to be. A farther away star should even be farther away even more at this time. However, the difference is negligible considering it takes another 13.8 billion years for the Hubble Constant value to decrease by half what it is now.

A tired light interpretation is also complex and further speculation by both approaches has promise in combining into a more complete theory.

The more complete theory is not free of modification. The established interpretation of the Schwartzschild singularity is that gravity having enough mass causes it to shrink within a volume of space too small to be defined. Its interpretation as here proposed is gravity is constitutive of work energy spent as consistent with the law of conservation of energy, as according to the established theory of thermodynamics. A decrease in gravitational mass of the singularity is also shown consistent with more detailed analysis of the relativistic factor of the Schwartzschild Metric.

THEORIES OF MOTION

Circular motion was conceived in ancient times as divine, as seemed evident of stars orbiting high up in the heavenly sky where they are above earthly chaos. Earthly substance is also considered as at the center of the universe below the heavenly stars.

As to explain the primary source of motion itself, Aristotle (384-322 BC) proposed an Unmoved Mover is its provider. What evolved from this proposal was a theory of emanation. Later, for instance, Robert Grosseteste (1168-1253) and Saint Bonaventure (1217-1274) proposed God first created lux, a corporeal form of substance that duplicates itself indefinitely. Motion consists as the duplication of form moving as energy waves in all directions. Lux constitutes the material form of substance by reflecting lumen, which is light. Light is also how God mediates between souls and bodies. As nature takes its course, it is not alienated from God, as He intervenes by emanating light from within.

Light, as according to Aristotelian physics, is thus the essential source of motion, as is distinguished from earthly substance having no inclination whatsoever to move without assistance. This theory was challenged by John Philoponus (about 490-570 AD) in asserting material substance is inclined to remain in motion without assistance. This idea identifies, in part, with inertia: whereby a state of non acceleration, as mass in relative motion or at rest, maintains unless it is changed by means of an external force, such as gravity or the collision from other mass in relative motion. However, even though it was an insightful idea for advancing theory, it was instead rejected by theologians with more influence in favor of the Aristotelian doctrine.

Light, in modern physics, is still an essential part of mass. The internal energy E of mass m is per light speed c squared, as by the equation $E = mc^2$. The difference of it from Aristotelian physics is the inert aspect of mass allows relative motion to continue, but light is still the primary source of change with regard to the internal nature of matter. Moreover, there is

still the distinction between light and matter. Matter varies in speed from interacting with light and other matter whereas light moves only at the same speed through vacuum space (except as apart from a material medium such as water or air, or from the influence of gravity).

Impetus and Inertia

A modification of Aristotelian physics did not fall on deaf ears outside of Europe. As during the golden age of Muslim academic culture in Persia, Avicenna (980–1037) concluded motion is an inclination transferred from the thrower that does not cease if it occurs within a vacuum. He obviously realized a decrease in motion requires a resistance to it, such as the presence of air. This reiteration of the Philoponus position identifies with a modern concept of inertia and momentum in view of empty space, but the idea of a plenum was still embedded in general thought. Philoponus and Avicenna, for instance, both conceded that the power of motion given to an object to move through a medium would eventually be used up.

Saint Thomas Aquinas (1223-1274) and Francis de Marchia (b. around 1285-d. after 1344) also accepted the position that motion maintains until it is impeded by the still presence of another object, or by some force such as gravity, but the object's ability to propel itself forward indefinitely with no additional assistance was granted by Jean Buridan (1295-1358).

Buridan proposed that motion given to an object from another object is sustained by the object until passed onto another object. He named this inherent property of motion impetus. He did not identify impetus with the energy of light, but he did offer a biblical justification for it in interpreting Genesis as stating God rested on the Sabbath after He created the world in six days. Because God rests, He allows His creation to sustain motion such that no longer is there any need for Him to replenish it.

Impetus theory is identical to the modern concept of relative motion except that Buridan referred to rest as distinct from motion, as to allow for an underlying medium such as the æther for a state of absolute rest, as for it to be distinguishable from the relative motion of all matter moving through it. His theory remains consistent with the modern mechanical interpretation of motion insofar as Buridan even stated impetus is proportional to weight times speed. A heavier object or a faster one thus has more impetus, which is similar to more momentum in view of modern terminology. Since gravity provides impetus to increase motion towards earthly mass, and earthly mass gives up impetus to escape from earthly mass, a cannonball falling through a hole through Earth is increased in impetus on the way down to the center of Earth the same as the cannonball gives up impetus to move up an equal distance to the surface at the other end. Such analysis later exemplified such periodic motion as the free swing of a pendulum, and of oscillatory motion

in general, as theoretically developed in the 17th century, but the concept of impetus was interpreted differently by other thinkers in the 14th century.

Nicole Oresme (1320-1382) maintained impetus is the temporal quality used up in motion by the inertness of earthly substance tending toward its natural place of rest, the Earth, as Aristotle had contended, and as evident of objects losing motion by falling to the ground. He further distinguished between an impetus given to the motion of the heavenly stars and impetus given to the violent and accidental motion of earthly events. However, he argued, contrary to Aristotle, that it cannot cause an object to accelerate to an infinite speed even in the vacuum of space because the impetus is spent during motion.

Oresme further considered Archimedes' principle of the lever whereby the position of a heavier object is placed nearer to the fulcrum for balance. In interpreting this principle as applying to the cosmos, Oresme referred to the Aristotelian idea that earthly substance tends toward the center of the world where Earth rests. However, the moon, sun and other celestial bodies moving about indicated to him that the center of gravity could shift. It thus is possible Earth can slightly shift in position as well. He further reasoned, however, that Earth's movement is not provable one way or the other. He further proposed the criteria two equal hypotheses should be the merit of simplicity, as Copernicus later advocated, but Oresme accepted a stationary earth in support of the common interpretation of the Bible at the time.

The Copernican Revolution

While impetus theory developed at Paris, France, more eloquent ways of describing nature developed at Merton College in Oxford, England. Such scholars as John Dumbleton, Richard Swinehead and Thomas Bradwardine proposed an abstract system of degrees and latitudes for analyzing qualities of nature, such as hot and cold, and various forms of motion according to quantity.

The intent of these Oxford scholars was for providing a mathematical description of processes rather than to claim their abstract calculations were actual laws of nature. They nonetheless provided the quantitative means for mathematically analyzing results of experiment in arriving at such concepts as constant acceleration and instantaneous velocity. This is particularly true with Domingo deSoto (1494/5-1460) applying the calculating technique of the impetus theories developed at Paris to refine the earlier calculations of Oresme for uniform acceleration of falling objects due to constant increase in impetus.

After this development, Nicholas Copernicus (1473-1543) proposed a heliocentric scheme of the sun at the center of the solar system where the

planets, including Earth, revolve around. His scheme was to be advanced by Johannes Kepler (1571-1630).

Aristarchus of Samos (b. around 310 BC–d. about 230 BC) advocated a heliocentric system of planets, including Earth, revolving around the sun. However, his scheme was overcome by the greater influence of Aristotle, who did not recognize the relatively great distance of stars for an incorrect conclusion based on the condition of parallax.

Parallax is the apparent change in position of an object caused by the observer moving here and there. The positional change appears greater for closer objects. Nearby scenery, for instance, changes rapidly for passengers looking out the window while inside a moving automobile, whereas a more gradual change in relative position occurs of more distant mountains. The change in the relative position of the sun appears not to change at all even though Earth rotates for day and night to occur. It also revolves around the sun for a change of seasons.

Copernicus did not consider parallax. Apart from it, observations of astronomers provided more and more data on the relatively closer positions of planets in our own solar system, such that the scheme of circles within circles for planets moving around Earth was more complicated. Copernicus thus proposed the much simpler scheme of Earth circling the sun. He also asserted no internal effects of Earth moving through space are detectable inasmuch as all relative parts move uniformly, which implies a principle of relative motion.

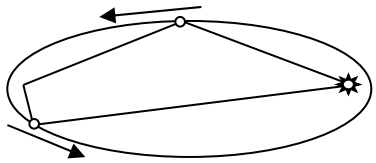
Publication of Copernicus's book *De Revolutionbus* occurred the same year of his death, but the book was outlawed along with later works by any of its defenders, including Galileo. Giordino Bruno (1548-1600) advocated, for instance, an entire world full of solar systems, and he further speculated stars move relative to each other, but that they are too distant from us for detection of their relative motion. However, he was burned at the stake for his outspokenness, whereas Galileo was merely sentenced to confinement for his defiance of the order.

Copernicus had nonetheless set forth a revolution in thought. Readers in Italy and elsewhere in Europe accepted *De Revolutionbus*. Simon Steven (1548-1620) of the Netherlands supported the heliocentric system with his book *De Hemelop* he published as early as 1608. However, the Copernican system was not faultless, as celestial data compiled by astronomers indicated planetary motion was not of true circles. As Copernicus revered the circle as a divine principle, his scheme included thirty-four epicycles. This weakened his argument of simplicity. A Copernican revolution had nonetheless begun. Ironically, Johannes Kepler, a so-called mystic who claimed to listen with a sensitive ear to the musical harmony of planets in motion, including Earth, was to defend it.

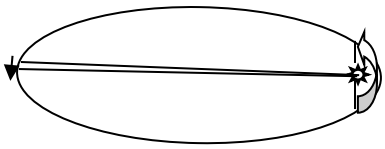
Kepler's Celestial Scheme

Kepler (1571-1630) was proficient in mathematics. Such skill enabled him to become an assistant to Tycho Brahe's (1546-1601) in plotting data of celestial movement. Brahe had rejected the heliocentric system in favor of the stationary Earth mainly because he could not detect parallax of the stars. He regarded Earth material as an inert condition of nature. However, he did accept a heliocentric system as applying for all the planets other than Earth revolving around the sun. As he maintained the sun and moon only revolve about Earth, it would only be another step to include Earth as also revolving around the sun.

Kepler studied the data compiled by Brahe and in 1609 proposed three empirical laws to describe it.



The first law is the planets, including Earth, move in elliptical paths instead of exact circular orbits around the sun. A circle transforms into an ellipse by separating its center into two foci, as a particular property of the ellipse is a total distance between two straight lines connecting the two foci to anywhere on the perimeter of the ellipse is always the same. As illustrated above, imagine a pencil maintaining a taut string between two locations for drawing a particular ellipse. The excess length of the string between the two loci determines the eccentricity of the ellipse. The total length of the two upper lines in the above illustration thus equals the total length of the two lower lines.



The second law refers to the distance between the sun and a particular planet: Equal area in equal time is swept between the sun and planet by the product of the distance of the planet from the sun and the different speed of the planet at the different distance. Planets thus move faster when closer to the sun in order for them to maintain the same amount of area per time,

as illustrated above, and as according to the mathematical equality $rv = r'v' = r(r/t) = r'(r'/t') = r^2/t = r'^2/t'$ with regard to distance-time relations of r and t between those of r' and t'.

The ellipses are not the same for each planet, but Kepler determined a common property as his third law. By it, a planet's orbital period squared is proportional to the orbit's semi-major axis cubed. Earth's orbital period, for instance, is one year, such that its semi-major axis is now defined as one astronomical unit (AU). For such units of measure a numerical value of the Earth's orbital period squared divided by its semi-major axis cubed is unity, as likewise for the other planets as well.

The average orbital distance is that of the semi-major-axis. The orbital period is orbital distance per orbital speed. Both distance and speed of orbit determine the orbital period. A planet with a semi-major axis that is twice that of Earth's has twice the orbital distance while moving at a slower rate equal to the square root of 2. Its orbital period is thus 2 (according to the longer distance) multiplied by the square root of 2 (according to the slower speed). The period squared is 2 squared multiplied by the square root of 2 squared, as $2 \times 2^2 = 8$. A twice more distance of the semi-major axis cubed calculates as $2 \times 2 \times 2 = 8$. Significantly, 8 divided by 8 is the same ratio of Earth's period squared and semi-major axis cubed, namely $8/8$ = unity.

It is possible Kepler could have had insight of the laws of nature, but they were developed in a progressive manner by other legends of history as Galileo and Newton. According to Newton's inverse square law of gravity, for instance, the orbital speed v relates to orbital distance r in the manner of a formula for centripetal acceleration: v^2/r. Orbital speed around the same mass at twice the distance is decreased by the square root of ½, such that its period per distance increases by a square root of 2. Twice an orbital period squared multiplied by twice an orbital distance is similarly 8 times greater, as is twice the orbital radius cubed.

Terrestrial Mechanics

Physics refers to the laws of motion as mechanics. Complementing the celestial mechanics of the planets is terrestrial mechanics. Its development also connects with gravity, as with determining the nature of bodies falling to Earth.

An experiment on gravity was performed as early as the third century BC by Strato. He determined that the sound of a body falling to the ground differs for the different height of fall. He thus surmised an increase in speed occurs during the fall.

An experiment in the thirteenth century was an attempt by Jordanus de Nemore (1225-1260) to distinguish weights between object according to the inclination of their angles of the planes on which they slide. His theory

of positional gravity and component forces considered work in relation to the position of a level apart from where it balances in a state of equilibrium.

Leonardo da Vinci (1452-1519), whose work did not all survive except for his notes, attempted to determine if the gravitational fall of an object is directly towards the center of Earth. He dropped two heavy objects from a tower in a failed attempt to find a decreased distance of separation.

Da Vinci failed to determine the direction of fall because the change in distance is too minute to detect with the instruments he had available, but he discovered instead a pyramidal increased speed of fall in equal intervals of time in analogy to counting stairs. However, from his notes, which might not necessarily reflect what he actually concluded, he incorrectly stated the distance of fall is proportional to the time instead of the time-squared.

Oresme, Galileo and others correctly determined the distance of fall is proportional to its time squared, but da Vinci might have only erred in his taking notes of his findings. To his credit, da Vinci seems to have been wise to the ways of nature. For instance, in anticipation of Newton's third law of motion, whereby force and the resistance to force are mutually the same, he suggested air and water use the same amount of force to resist movement.

Demonstratio, published in 1552 by Giovani Battista Benedetti (1530-1590), was a book that attempted to determine the nature of falling bodies analytically. He first assumed bodies of different weight fall at the same rate if they are equal in density, as composed of the same material. His proposal was contrary to Aristotle's doctrine that a heavier body falls faster than does a lighter one, but in a revised edition published in 1554 Benedetti changed his position to that of bodies of the same material but of different size do not fall at the same rate.

Perhaps critics influenced Benedetti to change his position, or perhaps geometrical considerations were apparent. If an object divides into two or more parts, for instance, more inside becomes part of the outside, which is also more exposed to atmospheric conditions. Since only the surface area changes instead of total volume of all its parts, this means the mathematical ratio of volume to its surface area is relatively according to its size. Smaller objects thus encounter more friction per surface area to volume or weight, which causes them to move more slowly through a medium, as is true of smaller particles falling through the atmosphere.

The difference in size of bodies falling at different rates is indicative of a medium. They fall at different rates in a medium, but they fall at the same rate in vacuum space. However, this is only true of such media as water and air. A medium with infinitesimally fine parts great in number could saturate between material parts. Thus, if the internal components of atoms are the same size and density with regard to the permeability of the medium, then it affects all of them equally. As it were, for supposedly not knowing the true

nature of atomic particles, Galileo Galilei (1564-1642) theorized instead that all bodies (regardless of the size, weight or material they are comprised of) fall, in vacuum, at the same rate.

The abstract analysis of motion at Merton College likely guided Galileo rather than the works of Benedetti. In any case, the hypothesis Galileo put forth provided a means of testing whether the laws of motion typify objects as moving through empty space, as would seem necessary for the planets in the Copernican system to move unopposed by a medium. Galileo therefore experimented with objects moving along planes and took notice of the free swing of pendulums to discover an appreciable amount of reduced friction tends to allow motion to maintain. He thus postulated the first two laws of motion that Newton would later formulate in his system of mechanics with regard to the inertia of continual motion and its acceleration as a change in either speed or direction, or both.

In order to test the equality of fall between masses, it is likely Galileo performed experiments, as is alleged of his dropping objects off the leaning tower of Pisa, but such a claim is uncertain. Nicole Cabeo (1585-1650) had conducted experiments in 1641 to confirm his claim that objects do not fall at the same rate. When informed of the experimental results, Galileo replied how difficult it is to attain accurate results from such experiments.

Galileo seemed to take other results of experiment for granted as well. For instance, Pierre Gassendi (1592-1665) had directed an experiment to be performed on a moving ship at sea to find out if an object follows a straight course of the ship while falling to the foot of the mast. His own experiment having already verified his laws of motion, Galileo confidently asserted the object would fall the same as if the ship did not move.

Still, to his credit, Galileo truly deserves the acclaim of pioneering the modern approach of establishing laws of nature according to observational facts rather than by ontology or abstract concepts of intuition.

Weighing the Debate

The idea all of space is filled with an undetectable medium is contrary to the empirical approach, but the new discoveries do not prove there is an empty space to move; it only affirms objects move as though empty space is before them instead of that it actually exists before them. Moreover, the new mechanics is not a complete explanation of reality. It does not explain, for instance, how it is possible for corporeal matter to attain and maintain a form in the manner it does. How, for instance, are elastic collisions possible without an internal force to maintain material form?

Such questions were still being pondered. Francis Bacon (1561-1626), for instance, questioned such concepts as a vacuum state with regard to the nature of matter. If matter consists of individual atoms, then how are they

kept intact? He concluded atoms need to somehow possess inner qualities by means of some intangible spirits arising from a medium of some sort to provide cohesion and form. He also advocated a primary role of science is to describe nature according to how it is observed.

Another philosopher who did uphold the atomic theory as an internal mechanism was Gassendi. He offered an atomic theory in view of primary and secondary effects. Secondary effects are with regard to the inertia and motion. Inertia is necessary to resist penetration and to change the motion of other atoms by means of direct contact. Atoms sometimes combine to produce various effects, such that our observable world is comprised of the secondary effects arising from a primary source that produces the form and cohesion of the secondary effects. The primary source is indeterminable by us even though it gives rise to the secondary effects that actually constitute the natural world of observation.

A philosopher who went so far as to advocate a plenum in view of the concepts of relative motion and inertia was Rene Descartes (1596-1650). He was well aware of the implications of these new concepts, but he opposed the vacuum state. He thus undertook the task of explaining relative motion and such effects as gravity in view of the plenum.

Since motion through a plenum is by reason necessarily circular, the Cartesian universe contains vortexes that differ in size and rotational speed. Exchanges occur by smaller invisible vortexes accelerating to greater speeds in determining the weight of heavier ones, and the visibility of the world is determined by the size of our nerves extending from our brains.

Descartes further postulated conservation of motion, which is similar to conservation of momentum in that in a collision between two masses the change in speed of the greater mass is less than the change in speed of the lesser mass, but more change in speed occurs to the lesser mass to balance out the less change in speed of the greater mass. Momentum as conserved is evident of the Cartesian philosophy inasmuch as Descartes considered an iron ball in the front of a row of them transfers its motion by collision to the end ball, as consistent with wave action. However, there is also inelastic collision to consider as well with regard to conservation of momentum and conservation of energy.

By inelastic collision motion ceases unless the collision involves some other influence as, for instance, a creation of radiant heat. In this case, it is possible that motion is conserved in the observable world in the form of a potential detectable by our senses in contrast to its underlying mechanism. In this regard it seems possible matter can somehow break apart in a way it evades our senses for empirical detection. In order to maintain conservation of momentum, the breaking apart of matter needs to occur by collisions in opposite direction only with other visible matter according to cancellation

of momentum in opposite directions. Momentum is conserved, but energy is only conserved if the invisible medium is affected such that it forms new matter in place of the old matter.

Modern theory has similar issues with regard to the concept of dark energy that somehow increases to increase the rate the universe expands at. There are also virtual particles theorized according to a probability with no effects as causally determinable. An underlying mechanism to explain all the phenomena of the natural world is thus provided by way of a virtual field. It could be used, for instance, to explain gravity by means of virtual particles moving undetected away from matter in the way of creating vacuum effects for both real particles and other virtual particles filling the otherwise partial vacuum of space. The virtual particles are rejected in creating a gravitational potential in the unique manner of maintaining conservation of momentum and energy of our observable world.

NEWTONIAN MECHANICS

Although Isaac Newton (1642-1727) is considered the founder of Classical Newtonian Mechanics, there is nearly no part of it, if any, that had not been thought of by someone else. His first two laws of motion, with regard to momentum and force, are attributable to the works of Buridan and Galileo. John Wallis (1616-1703) explicitly stated the second law in 1603. A third law of motion, regarding mutual action and reaction, was similarity offered by Leonardo da Vinci (1457-1515) in claiming air and water equally resist each other. Robert Hooke (1635-1703) claimed he suggested to Newton the inverse square law of gravity, which Newton then formulated according to Kepler's planetary laws of motion.

Newton stands out nonetheless as outstanding for his contribution in advancing theory. It was essentially a comprehensive formulation of ideas that resulted in the unification of Kepler's heliocentric scheme of the solar system in accordance with relative motion and gravity as forces of nature.

Laws of Motion

In addition to the concepts of absolute space and absolute time as a means to determine events according to standard units of measure, Newton also believed the material content of the universe always stays the same. It does not change by being in relative motion, under the influence of gravity, or by any means whatsoever. From this conservation of mass, he postulated three laws of motion:

1. Law of inertia: objects in a non accelerating state of relative motion or rest remain as such until acted on by an external force, such as by either gravity or collision with other mass
2. Force is the product of mass m and acceleration *a*, as per time t with regard to acceleration
3. An equal and opposite reaction occurs with every action.

The law of inertia is expressed as the product of mass m and its velocity v as momentum P. Hence, the first law is according to the equation P = mv. By this law, momentum remains unchanged until acted on by another mass or external force.

With regard to the second law, the amount of force F used to change momentum is the product of mass m and acceleration *a*, as according to the equation F = ma.

A change in velocity per time determines acceleration *a* such that it is possible a quick enough fly exerts more force from changing speed from at rest to fifteen miles an hour than does someone who throws a heavy brick twenty miles per hour. However, since the brick has far more mass than the fly, more force is generally applied to it than to the acceleration of the fly. More definitively, force is per time and per mass. The same change in speed of twice as much mass in twice the time is the same amount of force, as the lesser mass changes at twice the rate:

$$F_1 = \frac{m(\Delta v)}{\Delta t} = F_2 = \frac{2m(\Delta v)}{2\Delta t}$$

The Greek delta letter Δ denotes change, as change in velocity from $v_0 = 0$ to v_1, and as change in time from say $t_0 = 0$ to t_1.

Since velocity includes both direction and speed, the change in velocity can either be a change in speed or a change in direction, or a change in both direction and speed. A rocket moving in a circle, for instance, is constantly accelerating by means of a constant force. The rocket could also constantly increase in speed by the same force. Additional force could also increase the rate of circular acceleration.

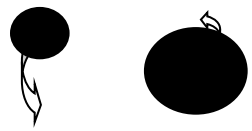
Galileo had previously established these first two laws. Newton added the third one: the law of mutual force. Hence, if a force acts on a mass, the mass reacts with an equal and opposite force for a change in momentum of the rocket caused by the rocket fuel to result in an equal amount of change in momentum of the rocket fuel in the opposite direction, as the rocket fuel would otherwise be inexhaustible.

From the mutual action and reaction between masses is conservation of momentum. Conservation means staying the same, and conservation of momentum means total momentum of all mass in any particular direction never changes by the action of one mass on another. The action can either be a collision of two or more masses or a force such as gravity. If a greater mass collides with a lesser mass, conservation of total momentum of the action is maintained by the change in velocity of the greater mass in one direction being relatively small and the change in velocity of the lesser mass

in the opposite direction being relatively large. Mutual changes in each of the momentums is according to the equation

$$M(\Delta v) = m(\Delta V)$$

Change in velocity of the greater mass M is thus less than the smaller mass.



Consider the moon orbiting Earth as an example of equal changes in momentums of masses caused by their gravitational influence on each other as mutual. In this case, a relatively slower moving Earth being more massive than its moon results in a change in direction of the moon being a greater change in velocity instead of change in direction while still having greater speed. In effect, the moon moves in a relatively large circular path around Earth while Earth moves in a relatively small circular path within the larger. As to why Earth never circles the moon, it is because Earth is too slow with its changing of direction at each new position of the moon.

Centripetal Acceleration

Centripetal acceleration is a constant change in direction resulting in a circular path. In 1966, Newton formulated it mathematically, but he delayed the publication of his work for many years. Christian Huygens formulated it independently for his publication of it in 1673, but it was Newton who used it for the unification of celestial and terrestrial mechanics.

Consider, as by Newton's first two laws of motion, a particle tends to move in a straight line, but it actually moves peripherally instead around a fixed point because of a centripetal force constantly acting on the particle in changing its direction. The centripetal force is any agent, such as gravity or whatever, preventing the particle from escaping its orbit. The mathematical expression is

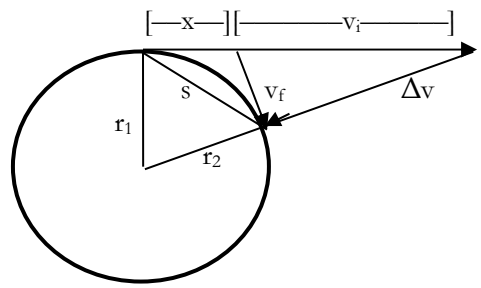
$$a = \frac{v^2}{r}$$

Respectively, the letters *a*, r, and v represent the rate of acceleration, orbital radius and orbital speed, respectively.

Although centripetal acceleration is a particular form of acceleration, it equates to any form of acceleration generally expressed by the equation

$$a = \frac{\Delta v}{\Delta t}$$

Acceleration is thus generally a change in velocity (as speed or direction or both) per change in time.



As illustrated above, a system moves along the arc at constant speed v in time T from initial velocity v_i to final velocity v_f, in relation to triangles. Radius r_1, an extended tangent of r_1 to the right, and radius r_2 extended to the tangent of r_1 form a right triangle. Another right triangle forms from the extension of the tangent of r_2 to the tangent of r_1. Because of the common vertex at the right, it is a smaller-upside down-right triangle similar to the first one. All ratios of corresponding parts thus equate. Because distance results from the product of time and speed, the vector directions v_i and v_f represent both distance and velocity. The other leg of the triangle with legs v_i and v_f is a vector direction pointing towards the center of the circle as representative of a change in velocity, and it is therefore denoted as Δv. The ratio of $r_2 + \Delta v$ and $x + v_i$ of the larger right triangle is the same ratio of Δv and v_f of the smaller one such that

$$\frac{x+v_i}{r_1} = \frac{\Delta v}{v_f}$$

The values x, v_i and v_f are interpreted as either speed or distance for $x + v_i$ and v_f to relate respectively as v and vT, where T is the time of acceleration.

These relations are according to a smaller distance and a less time of acceleration. For the smallest possible angle between radii, the arc between r_1 and r_2 converges with the line segments s and v_f at the limit for shortest time of acceleration to equate in the manner

$$\frac{\Delta v}{vT} = \frac{v}{r}$$

$$a = \frac{\Delta v}{T} = \frac{v^2}{r}$$

Centripetal acceleration thus equals a constant change in direction towards the center of the circle.

Kepler's Scheme

Centripetal acceleration relates to force, as with regard to a centripetal force. Since force is defined as F = m*a*, centripetal force similarly equates as

$$F_c = \frac{mv^2}{r}$$

Note: F_c increases for smaller r, as for faster change in direction at the same speed around a smaller circle.

Another nature of force is gravitational, which is also centripetal with regard to it maintaining orbital motion. This connection was the means that enabled Newton to unify Kepler's celestial scheme with the forces of nature for the formulation of a theory of gravity.

Newton used Kepler's planetary laws of motion to derive the inverse square law for gravity. Kepler's third law, in particular, relates the planetary orbits in our solar system. According to it, the square of the period of any elliptical orbit equals the cube of the mean distance of the planet from the sun. The ratio of the time squared of Earth's revolution around the sun to the cube of its distance from the sun (as from Earth's center of mass to the sun's center of mass) is thus the same as that of Mars or any other planet in the solar system.

Kepler's third law in mathematical terms is

$$A^2 = kr^3$$

The letter k represents a constant of proportionality for the proportionality between the period of revolution A squared and the mean radius r cubed of the semi-major axis of an elliptical orbit.

If the ellipse is a circle, which it can be, then r is the radius of a circle. As for simplicity, let the distance of orbit be that along the circumference of a circle such that the orbital distance is π times twice the radius of the circle. (Since the mean orbital speed for any other ellipse involves a more complex explanation, it is left as a task for the reader to verify.)

The time or period of revolution of the planet can also be expressed in terms of distance divided by orbital speed in the manner

$$A = \frac{2\pi r}{v}$$

Squaring and combining equations gives

$$A^2 = \frac{4\pi^2 r^2}{v^2} = kr^3$$

Solving for centripetal acceleration by multiplying the last two sides of the equation by the velocity-squared, and dividing by k and by r to the fourth power, gives

$$\frac{v^2}{r} = \frac{4\pi^2}{kr^3}$$

Centripetal acceleration according to Kepler's scheme is thus proportional to $4\pi^2/kr^3$.

Further multiplying both sides of the equation by mass m relates it to centripetal force in the manner

$$F_c = \frac{mv^2}{r} = \frac{4\pi^2 m}{kr}$$

According to Newton's third law of motion, the gravitational force between two bodies of mass is the same. Since r is a common distance separating the combined forces of masses m_1 and m_2, they combine by multiplication for the total force to equate in the manner

$$F_g = \frac{4\pi^2 m_1}{kr} \cdot \frac{4\pi^2 m_2}{kr} = \frac{16\pi^4 m_1 m_2}{k^2 r^2} = \frac{G m_1 m_2}{r^2}$$

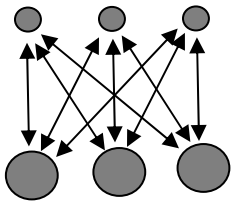
This equation expresses Newton's general form of the inverse square law of gravity, with G as a constant of proportionality in place of $16\pi^4/k^2$. Its value has been determined to be 6.67428(27) x 10^{-8} cubic centimeters per grams and seconds squared.

A Galilean Interpretation

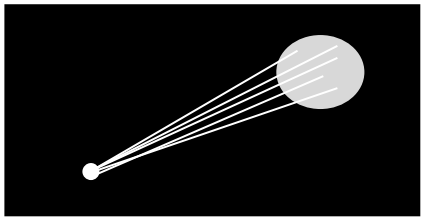
A more analytical and less mathematical explanation of Newton's law of gravity is according to the discovery by Galileo that all bodies of mass fall at the same rate.

Galileo's findings indicated gravitational force from and to each mass is proportionally the same. For instance, twice as much mass requires twice as much gravitational force such that the force distributed per mass is the same. The rate of fall toward a particular mass is thus the same for all mass. However, the rate of fall depends also on a total amount of mass doing the gravitating. Another Earth having twice the mass of our Earth, for instance, contains twice as much force to double the rate of acceleration. Moreover,

another moon with twice the mass of our moon has twice the force of our moon. Together, the other Earth and moon have four times as much force to attract each other. As illustrated above, simply divide Earth and its moon each into any equal number of parts and count the total number of mutual attractions between all Earth and moon parts. This is simple multiplication, as the total force of attraction between the Earth and its moon is simply the number of moon parts multiplied by the number of Earth parts according to the illustration below. However, since the result differs as to the number of parts arbitrarily considered, a constant of proportionality is included for consistency, as for specifying the unit of measure of a part, such as a gram, centimeter, second and so forth.



Although the total force between each mass is the product of the total amount of each mass, it includes the mean distance between them as well, as an aspect of the equation known as the inverse square law. The law is consistent with how radiation spreads from its source of emission. Similarly, if gravitational force spreads in the manner of say light from its source, then its intensity in relation to the surface area of an imaginary spherical surface expanding from the source of emission decreases in accordance with an increase in surface area, as $4\pi r^2$, for the longer distance r, as depicted below. Newton's inverse square law formula for gravity is thus again of the form $F_g = Gm_1m_2/r^2$.



Explaining Gravity

Newton was not content with his inverse square law for gravity as only able to explain action of one mass on another as occurring at a distance. He considered action at a distance as casually absurd, as he therefore attempted

to explain gravity more completely in the manner of a contiguous action of masses affecting the space between them, as for the action between masses to somehow result in their mutual attractions.

Although Newton attempted to explain gravity according to an agent acting between mass for contiguous action to occur, he was still reluctant to recognize an æther filled space as a medium for wave action. He regarded the presence of æther as an obstacle to the free movement of planets, and to the natural motion of mass in general, unless it could be rare in content. He considered instead an æther that is comprised of extremely fast moving particles of minute mass for internal elasticity of containment. In theory, a particle of less mass can have a greater speed while it moves with the same momentum as does the more massive, slower moving particle, such that a containment of the former can allow less resistance to movement of other mass than would a containment of the latter. The æther is thus allowed to exist only as nearly massless particles of extremely rapid, elastic collisions. In being nearly massless as such, they allow ordinary particles to move as in a path relatively free of content before them.

Newton's æther has merit and possible truth inasmuch as gravity could very well be the result of a vacuum effect from the interaction of æther with mass. Since mass accelerates speeds of lesser inert æther particles, the faster particles are more inclined to escape, as for leaving a vacuum effect in their wake. However, escaping particles needs to somehow be replaced in order for the process to maintain as continuance.

Kinematics

Kinetic derives from the Greek word kinesis that means motion, but it was not applied until a much later time, as about 1850 by Lord Kelvin.

Gottfried Leibniz (1646-1716) called the energy of motion "vis viva", meaning the living force. Willem's Jacob Gravesande (1688-1742) found the penetration of clay by equal weights that are dropped from different heights is in proportion to the difference in speeds squared of each weight. Emilie du Chatelet (1706-1749) explained this result as work energy of the change in speed of mass used to move a mass quantity a distance proportional to the inertial resistance causing the change in speed.

With calculus, Joseph Lagrange (1736-1813) found in 1811 there is an additional difference of Vis viva mv^2 and potential energy of momentum mv by a factor of 2. The factor ½ for kinetic energy $K = (½)mv^2$ came from Gustave Coriolis (1782-1843) in 1829, even though a kinetic theory of gases was developed earlier by Johann Bernoulli (1667-1748) in accordance with Newton's laws of motion.

Consider a moveable partition separating two gases into equal volumes of cubic space. Each gas has the same number of molecules, but molecules

of one gas have only a fourth the mass moving at twice the speed, on the average, than the more massive molecules of the other gas. Since $(½)m(2v)^2 = (½)(4m)v^2$, the gases have the same kinetic energy, and since one fourth mass at twice the speed strikes the partition twice as often, the momentum of action on both sides of the partition per time of action is the same, such that the partition does not move.

Another condition is that of elasticity. In contrast to an elastic collision where masses reverse momenta, there is an inelastic collision where masses combine as one in the manner

$$Mv_1 = (M + m)v_4$$

$$\frac{M}{M+m} = \frac{v_4}{v_1}$$

Let M = 2m. Hence

$$\frac{2m}{3m} = \frac{v_4}{v_1}$$

$$2v_1 = 3v_4$$

$$v_1 = \frac{3}{2}v_4$$

$$\frac{1}{2}(2m)\left(\frac{3}{2}v_4\right)^2 \neq \frac{1}{2}(3m)v_4^2$$

$$\frac{9}{4}mv_4^2 \neq \frac{3}{2}mv_4^2$$

Kinetic energy is thus not conserved in inelastic collision. However, energy is still conserved if it converts into another form, such as heat or electrical.

Conservation of kinetic energy of elastic collision is proven with three equations according to Newton's laws of motion:

(1a) $$(nm)v_1 + mv_2 = (mn)v_3 + mv_4$$

(2a) $$\frac{1}{2}(nm)v_1^2 + \frac{1}{2}mv_2^2 = \frac{1}{2}(nm)v_3^2 + \frac{1}{2}mv_4^2$$

(3a) $$v_1 - v_2 = v_4 - v_3$$

Accordingly, n denotes any positive real number such that the product nm denotes any mass quantity proportional to m. The left sides of equations

(1a) and (2a) represent the momentums and kinetic energies of the masses before collision. The right sides of the equations represent the same after collision: v_1 and v_2 are the velocities before elastic collision, and v_3 and v_4 are the velocities after collision. Equation (3a) defines a condition of elastic collision such that the difference in relative speed between masses remains the same after collision as before collision, but they have been reversed in their original directions.

To simplify, both sides of equations (1a) and (2a) are divided by m, and both sides of equation (2a) are multiplied by 2, obtaining

(1b) $$nv_1 + v_2 = nv_3 + v_4$$

(2b) $$nv_1^2 + v_2^2 = nv_3^2 + v_4^2$$

(3b) $$v_1 - v_2 = v_4 - v_3$$

To prove kinetic energy is conserved in elastic collision, the task is to derive equation (2b) from equations (1b) and (3b).

Equation (1b) is first rearrange by subtracting v_2 and nv_3 from both sides of it to obtain

$$nv_1 - nv_3 = v_4 - v_2$$

$$n(v_1 - v_3) = v_4 - v_2$$

By dividing both sides of the resulting equation by $(v_1 - v_3)$ a solution of n is obtained as

$$n = \frac{v_4 - v_2}{v_1 - v_3}$$

Rearranging equation (3b) by adding v_2 and v_3 to both sides of it obtains

$$v_1 + v_3 = v_4 + v_2$$

Dividing both sides of it by $(v_1 + v_3)$ obtains

$$1 = \frac{v_4 + v_2}{v_1 + v_3}$$

The product of the two solutions n and (1) gives

$$(1)n = \left[\frac{v_4 - v_2}{v_1 - v_3}\right] \cdot \left[\frac{v_4 + v_2}{v_1 + v_3}\right]$$

Multiplying the first and last equalities of this equation by ($v_1^2 - v_3^2$) obtains

$$n(v_1^2 - v_3^2) = v_4^2 - v_2^2$$

$$nv_1^2 - nv_3^2 = v_4^2 - v_2^2$$

Adding $nv_3^2 + v_2^2$ to both sides of this result obtains

$$nv_1^2 + v_2^2 = nv_3^2 + v_4^2$$

Multiplying both sides by m obtains

$$(mn)v_1^2 + mv_2^2 = (mn)v_3^2 + mv_4^2$$

(2a) is thereby derived from (1a) and (3a) in proving conservation of kinetic energy in elastic collision from the laws of conservation of momentum and conservation of the difference in relative speeds after collision.
The proof also assumes conservation of mass whereby no exchange of mass occurs between masses. An exchange of mass between masses due to their elastic collision is conditional to Einstein's special theory of relativity, as another modification of Newtonian Mechanics.

The Escape Velocity

Kinetic energy relates to Newtonian Mechanics in providing a simple derivation of an escape velocity v_e:

$$\frac{1}{2}mv_e^2 = \frac{GMm}{r} = mv_o^2$$

$$v_e = \sqrt{\frac{2GM}{r}} = v_o\sqrt{2}$$

A mass m can thus overcome the gravitational binding energy of relative motion if the speed v_e of escape is at least the square root of 2 times more than the orbital speed v_o at radius r from the center of mass M.

NATURE FROM WITHIN

Sometime in the thirteenth century Giles of Rome (b. before 1247-d. 1316) proposed an atomic theory according to the principle no form of matter exists smaller than a minimal quantity of substance. He tried to support his theory with the investigation of a vacuum state. He was unable to verify his theory, but investigations of the vacuum state continued, eventually leading to Boyle's Law, the kinetic theory of gasses, the development of chemistry, the laws of thermodynamics, and the classical theory of the atom. There is thus the result of the hydrogen atom being a minimal quantity, except that there are also such subatomic particles as electrons, neutrinos and so forth.

The Kinetic Theory of Gases

Giovanni Batiste Beliani (1582-1666) debated with Galileo on how to explain vacuum effects. In the year 1620 the debate focused on the effect of air weight. It was known water could flow higher up from a vessel through a tube lying over a hill. However, if the top of the vessel was sealed, a partial vacuum occurred at the top of the vessel from the leakage of water at the bottom, as to restrict the water from flowing through the tube. It was suggested by Galileo that attractive forces exist between the water and the vessel, whereas Beliani believed the air outside exerts pressure on the water attempting to come out the tube at its other end. Beliani was correct, as further investigation of the vacuum state led to such new inventions as the mercury barometer by Evangelista Torricelli (1600-1647) and the air pump by Otto von Gueriche (1602-1686).

Torricelli used the barometer to compare pressure of air at sea level to its pressure higher up in the mountains. Not only did he find a difference; he further discovered the pressure changes with a change in the weather.

Gueriche invented the air pump to produce more vacuum in order to measure more work capacity of outside air pressure. The outcome was him using the barometer in 1660 for forecasting the weather.

More experiments occurred in England, as Henry Power (1623-1670) and Richard Townely (1629-1707) examined air below atmospheric pressure in discovering the product of pressure and volume stayed constant. Robert Hooke (1625-1703) experimented with air above atmospheric pressure to determine the same result. Robert Boyle (1627-1691) and Hooke confirmed the nature of gas pressures more in general. Boyle then proposed, in 1662, the law that the product of volume V and pressure p of gas is constant at a fixed temperature T, as expressed by the equation $pV = k$. (In France, Edme Mariotte (d. 1684) also proposed this law in 1676.)

A constancy of volume-pressure relates to Newton's laws of motion in that a sphere with twice the radius of another has eight times more volume and four times more surface area, but it also has twice the average distance for a particle to reach the surface for it to collide half as often. The intensity of collisions in the larger sphere in relation to twice distance and four times more surface area is thus one-eighth as much pressure. Since the decrease in pressure is the same as the increase in volume, their product is the same for all spheres.

To understand the relation in terms of kinematics, consider pressure p as a force per area, as pounds per square inch where weight is synonymous with the force of gravity. The latter further equates in terms of a centripetal force mv^2/r, as the product of mass m and velocity v squared per distance r of orbit. Pressure thus relates as mass times velocity-squared per radius r of orbit and per area d^2 of containment. Because the product of the radius and area is dimensionally the same as a volume, $pV = (rd^2)(mv^2/rd^2) = mv^2$ is twice the kinetic energy $K = (½)mv^2$.

What followed from Boyle's law is a relation of heat and temperature. Although generally attributed to the motion of atoms or molecule, all that physicists essentially knew about them is the former is a quantity contained of the mass and the latter is a measure of how much a particular substance such as mercury expands in relation to heat absorbed. Now, with Boyle's law, it appeared they could be understood in mechanical terms of mass and relative motion.

Daniel Bernoulli (1700-1782) initiated the kinetic theory of gases along with his study of hydrostatics. Bernoulli advocated a mechanical theory in analyzing the kinematics of molecules in analogy to the collisions of billiard balls, despite general regard at the time that such a process is too simple to resolve the complex nature of reality.

Although the pressure-volume product was determined as constant for a particular temperature, it was still questionable as to whether the constant k is the same for different temperatures. Guillaume Amontons (1663-1705) foresaw the ideal gas law $pV = nkT$ before it became established, as stating in a 1702 paper that a product of pressure p and volume V equals a product

of temperature T for the same constant k, such that either pressure, volume or both increase with the increase in temperature. He further considered a zero temperature in relation to zero pressure, which anticipated an absolute temperature scale established about a century and a half later.

Another form of the law, as Charles' law, became the law of volumes whereby the volume of a gas container increases with temperature instead of an increase in pressure. The law was proposed by Jacques A. C. Charles (1746-1823) in 1787. It along with Archimedes' principle of buoyancy led to the invention of the hot air balloon. It was also established quantitatively by Joseph Louis Guy-Lussac (1779-1850), in an 1892 publication, whereby one degree centigrade change in temperature corresponds to a change in volume of the same pressure occurring as one part in 273 parts volume of gas.

An ideal gas law was hinted at by Amontons in 1702. It was explicitly stated by Paul Emile Claypeyon in 1834 in relation to Boyle's and Charle's laws. It was later derived in 1856 by August Karl Kronig (1822-1879) in accordance with the kinetic theory of gases, and also in 1857 by Rudolf Clausius. However, Johannes van der Waals (1837-1923) showed in 1873 that the law is not ideal because of electromagnetic effects also influencing the results. Indeed, it would seem that two different size spheres having the same density of molecules of the same mass and average speed would have the same temperature, as opposed to the same amount of molecules, but it depends on what constitutes the measure of temperature. If pressure on the surface area per volume determines it, then the ideal gas law applies. If it is only pressure per surface area, then the ideal gas law does not apply.

Conditions are more complex inasmuch as the kinetic theory of gases relates to the number of molecules and average molecular speeds squared. Twice the average speed of the same molecules thus relates to four times as much absolute temperature, as each molecule strikes the surface area twice as often with twice the momentum. An increase in the number of molecules instead of their speeds indicates, as according to theory, that energy density is linearly related to temperature. However, if the energy responsible for the temperature consists of electromagnetic radiation, it is shown by a later law, the Stephen-Boltzmann Law, an increase in electromagnetic energy density is proportional to the fourth power of the increase in temperature. Double the density, for instance, increases absolute temperature sixteen times. How this result is possible is generally explained as temperature being only one of various forms to which energy converts.

A criticism of the kinetic theory of gases itself was that the violent internal motion of matter would cause it to explode every which way. No counter argument came forth until the middle of the 19th century when Clausius explained that collisions between minute particles great in number obstruct their mean free path of escape. Constant collisions keep reversing

directions for the total distance moved to be much longer than the direct outward distance itself. The kinetic theory of gases, however, was not to be accepted until revived in a statistical form by Clausius, Maxwell, Boltzmann and others in a later part of the 19th century.

The Substance of Heat

Heat as molecular motion had many proponents, including Boyle and Hooke, but until the later part of the nineteenth century a theory of heat as a substance was more accepted. The criticism pertaining to an inner, violent molecular motion causing matter to explode in all directions was influential. For this reason and others, the idea heat is a particular substance absorbed and emitted by matter instead of only an internal movement of the internal components of matter remained popular.

Both Boyle and Newton proposed fire consists of material substance, as the residue caused to burn and produce heat. Boyle experimented to find substances that did not decompose, which he defined to be an element.

Etienne Francois Geoffrey (1672-1731) advanced in 1718 the idea that a particular substance of a compound (such as carbon of carbon monoxide) is replaceable by another substance (as by hydrogen to convert the oxygen of carbon monoxide into water molecules). He then derived a table of 16 columns in demonstrating an order of replacement of known substances. This effort evolved into a table of affinities wherefrom element A instead of element B combines with the element C because elements A and C have more of an attraction for each other than do elements B and C.

The table of affinities was used by Joseph Black (1728-1799), Henry Cavendish (1731-1812) and Joseph Priestley (1731-1810) to discover nearly all the elements of permanent gases. Their discoveries further enabled an explanation of the oddity of weights from combustion and calcinations of different materials that result from the combination of different elements to produce various combinations of exchange.

Newton had considered an inert matter contained by elastic forces of some kind of æther, and he offered an explanation of heat as a repulsive force decreasing in inverse proportion to the distance between molecules. He argued that particles of light excite the æther, which then convey the excitement onto matter to produce heat along with other effect. He even supported the connection of æther with heat and light by experimentation on the bases a vacuum did not prevent a transfer of heat (as radiant heat requires no material medium to move through space).

Attraction and Repulsion

Newton was also influential to future theory for advocating a dualistic principle of both attractive and repulsive forces of nature: one of gravity

and another of heat. Stephen Hales (1677-1761) developed the idea both attractive and repulsive forces consisting of two kinds of matter tend to become balanced in a state of equilibrium. His idea was to have profound influence on Benjamin Franklin (1706-1790) and others with regard to two fluid theories of electricity and magnetism.

Theorists were generally inclined to relate all forces as substances of a particular kind determining the internal nature of matter. In the 1740s, for instance, Franklin proposed electrical phenomenon is an elastic fluid of mutually repulsive particles. Matter is electrically neutral if it contains the right amount of particle fluid, repulsive if it contains an excessive amount, and attractive if deficient of it. Gowin Knight (1703–1772) also proposed a fluid for magnetism with the propagation of light as the vibrant motion set up in the fluid.

William Cullen (1710-1790) advanced the idea forces of matter result as various modifications of æther pervading matter. He proposed electricity, light, heat, gravity, magnetism and so forth emanate as various forms of æther that is itself gravitationally weightless and distinct from matter, as for such effects to deviate from the equilibrium state of gravity.

Latent Heat

Cullen's student Joseph Black considered heat, light and so forth as modifications of æther. In support of his consideration, he systematically studied combustion and calcination of different elements in pioneering the science of calorimetry.

Black's study mainly pertained to temperature and heat. Newton had defined a quantity of heat as the amount of time taken to lower a substance to room temperature. Black took this definition to mean that heat can be measured as the time required for either dropping or raising its temperature to a certain amount. He thus measured a certain quantity of water according to the amount of time it takes to raise its temperature by one degree. The temperature, however, did not change in such cases as involving a change from water to ice, or vice versa, and from this find Black proposed the concept of latent heat.

This latent form of heat had already been noticed by Daniel Gabriel Fahrenheit (1686-1736). He discovered water remained in the liquid state while cooling at the freezing point (as now 32 degrees Fahrenheit), but it also congealed into the solid state above this temperature by way of shaking the container. This find that Black verified on his own in 1761 suggested heat can be stored as a latent form of energy without a rise in temperature. A mixture of ice and water, for instance, need not change in temperature with change in heat if the change in heat is relatively slight.

From Phlogiston to Caloric

In aiming to disprove a theory that phlogiston is a primary substance of fire, Antoine-Laurent Lavoisier (1743-1794) probably introduced caloric in naming the main substance of heat. George Ernst Stahl (1660-1724) had proposed phlogiston is a substance whose violent motion produces heat and flame when passed into the air from the dispersing of matter. Plants absorb and recycle it. There is truth to this idea if we identify phlogiston with carbon, which Stahl did, but he also claimed phlogiston is the only element that can exist by itself not as a compound, and that it is the catalyst for all processes of combustion.

Stahl's generalization was open to dispute since some substances lose weight during calcinations whereas others gain weight. Thus, in some cases, phlogiston needs to be of positive weight; in other cases, it needs to be of negative weight.

A resolution to this quandary was the table of affinities first presented by Geoffrey; wherefore came many chemical discoveries. One of particular pertinence was the discovery of oxygen. By it, physicists no longer needed phlogiston to explain the changed state of matter, as calx plus phlogiston producing metal, for instance, could more easily be explained as calx giving up oxygen to become metal; or, conversely, metal absorbing oxygen to become calx. More experiments by Lavoisier indicated conversion of sulfur, phosphorus and arsenic into oxides results in their gain in weight because there is a decrease in the weight of air.

In disclosing the inadequacy of phlogiston theory, Lavoisier held the general belief of Cullen and others that æther acts as a weightless elastic fluid that is not influenced by gravity, and it is primary responsible for such effects as light, heat, electric-static repulsion and so on. He followed up experimental results of Cullen on cooling effects of such volatile liquids as alcohol by vaporization to discover, independently of Black and Fahrenheit, the temperature of ice did not increase while changing to a liquid state. In replacing phlogiston with caloric, he proposed an element such as oxygen has more affinity for absorbing caloric than does another. By ice changing to water, or by water vaporizing into the atmosphere, the base material maintains a slight portion of its coolness. Caloric thus seemed to provide a more consistent explanation of how change in weight occurs of substances, but atomic theory was to provide a different explanation.

From Caloric to Atomic Theory

It was evident substances combine in definite proportions, as a precise amount of oxygen combines with a precise amount of hydrogen. This find was named by Joseph Proust (1754-1826) the Law of Definite Proportions. It and a similar law led the way to the modern theory of the atom.

The similar law is the Law of Multiple Proportions proposed by John Dalton (1746-1844). According to it, the chemical elements consist of tiny particles called atoms. Atoms of a particular element are all of the same size, weight, mass, etc. that differ from those of other elements, but the different elements combine in ratios of simple whole numbers in forming chemical compounds. Dalton proposed a table of atomic weights of the six elements hydrogen, oxygen, nitrogen, carbon, sulfur and phosphorous. Hydrogen, as the lightest of these elements, was assigned the number one.

Another similar law, proposed by Gay-Lussac, is the law of combining proportions. He and Alexander von Humboldt (1769-1859) discovered that two volumes of hydrogen combine with one volume of oxygen to become two volumes of vaporized water with the same temperature and pressure. Gay-Lussac further studied data collected by Humphrey Davy (1778-1829) with regard to volume ratios obtained by combining nitrogen with oxygen. He experimented to further find a half gaseous volume of nitrous oxide is obtained by combining a volume of nitrogen with a half volume of oxygen of the same temperature and pressure.

Similar finds encouraged Gay-Lussac to conclude that gases combine in whole numbers ratios, as they also do according to weight. However, he did not explain why some whole number ratios differ from others. Why, for instance, does water vapor squeeze one volume of oxygen and two volumes of hydrogen into two volumes total?

Amedeo Avogadro (1776-1856) explained the ratio of whole number combos according to a hypothesis a gas with the same volume, pressure and temperature of another contains the same number of molecules. As to why two volumes water vapor is the result of two volumes of hydrogen gas and one volume of oxygen gas, he assumed molecules are formed from "solitary elementary molecules", or atoms. Since hydrogen gas consists of two atoms for every molecule, two hydrogen atoms combine with an oxygen molecule (as consisting of only one atom) to form a water molecule. The number of molecules per volume thus stays the same.

Avogadro's hypotenuse became known as Avogadro's Law. However, it was at odds with Dalton's atomic theory that assumed the compounds of elements are the result of like atoms repelling each other in allowing other kinds of atoms to occupy the space instead. Thus, Dalton and his followers were not to accept the concept that identical atoms combine in becoming a molecule. As it were, Avogadro's law failed acceptance until a fellow Italian, Stanislao Cannizzaro (1826-1920), pointed out in 1861 that the law could be used for a convenient table of atoms in simple ratios of whole numbers.

Rudolf Clausius (1822-1888) then helped promote the kinetic theory of gasses in explaining the vibrant motion of atoms is stable by being great in number, as each encounter between numerous atoms acts to slow the

mean free path of escape by constantly reversing their directions, which is consistent with an interpretation of gravity by Newton according to vibrant cells or vortices of æther having a zero total momentum internally for each cell, but which implies that space is indeed filled with an enormous number of miniature cells as a medium of interaction.

The Fate of the Caloric

The role of caloric in developing theory was to replace the phlogiston of fire to explain latent heat. The properties ascribed to the caloric were it consists of individual particles repelling each other, as flowing from hot to cold matter, as gravitationally attracted to matter, and as conserved. Thus an engineer named Nicolas Leonard Sadi Carnot (1796-1832) used the theory of caloric, as a form of æther, to derive theorems for a more efficient steam engine.

Postulating conservation of heat as caloric, Carnot theorized it flows from the hottest to the coldest parts of the mechanism performing work, as caused by the viscous flow of caloric. Since caloric is conserved, the process compares to a waterwheel turning by the flow of water that forever recycles. Similarly, because systems of the same temperature are unable to exchange caloric to perform work, the recycling of caloric is required. Adding more fuel, for instance, allows a hot steam engine to continually release caloric to perform work.

Carnot's conditions for efficiency were correct for the most part, but the conservation aspect of caloric is inconsistent with energy as conserved in that one form of energy merely converts to another. Caloric was thus to become discarded in favor of energy.

Neither physicist nor chemist had yet established the modern law of conservation of energy, but Count Rumford (1753-1814) had demonstrated an enormous quantity of heat results from boring cannon holes. Humphrey Davy (1778-1829) rubbed two plates of ice against each other to similarly demonstrate heat can be produced even inasmuch as no caloric should be available at a temperature below freezing. Moreover, no appreciable amount of change in mass or of its weight occurred in either of these experiments. Rumford thus proposed vibrant motion causes heat instead, whereas Davy considered heat results from the absorption of light. Davy also suggested a novel idea: that light combines with oxygen to become "*phosoxygen*", which can be interpreted as matter increasing in mass by absorbing light.

Conserving Energy

The main difference between conservation of caloric and conservation of energy is caloric does not convert into another form of energy whereas all energy does, as in view of its modern concept. This modern concept was

stated in 1841 by Julius Robert Mayer (1814-1878) as a force (then regarded as a varying form of energy) that merely changes from one form to another. It is thus neither created nor destroyed. He argued that the loss of kinetic energy during inelastic collision between masses transforms into heat.

James Prescott Joule (1818-1889) verified Mayer's argument in relation to friction. Heat that results from stopping motion by friction was common knowledge. Joule measured it quantitatively to conclude lost heat is due to work being used to overcome friction. It was also known that the flow of electricity through a highly resistant wire heats the wire. Joule established this effect quantitatively in 1841 in confirming current transforms into heat in mechanical units of work.

In 1847, Hermann von Helmholtz (1821-1894) addressed the scientific community in stating there is no such thing as a perpetual motion machine performing work without compensation for it in return. Simply put, given an isolated system, the internal energy of the system comprises, as stated in modern terms, the total of kinetic and potential energies of the molecules, which remain constant unless acted on by some external influence. Where the systems interact, a change in internal energy is according to the quantity of heat absorbed and the amount of work performed on the system, as by the equation

$$\Delta E = H + W$$

H denotes a quantity of heat, W denotes the amount of work performed, and the letter E proceeded by the Greek delta letter denotes the change in energy.

Note that one form of energy is related in terms of its potential. A ball at some height, for instance, has a gravitational potential. If it falls from the table, then its potential energy converts to kinetic energy. By the friction of the ball falling through air and colliding with the floor, the kinetic energy further converts into heat. Potential energy thus links to force with regard to such circumstances as position of mass. If the path of mass is circular, for instance, then changes in force and potential are zero with regard to a conservative field of force. However, there is also a concept of entropy to consider, as is distinct from potential energy, whereby a portion of energy is lost for useable work.

Entropy

Clausius, in 1850, reformulated the theorem put forth by Carnot for it to comply with conservation of energy. It was also reformulated in 1851 by William Thompson (1824-1907), renamed Lord Kelvin. In result, a concept of entropy was established as the second law of thermodynamics.

In view of conservation of energy, there is a condition of adding fuel to sustain a difference in temperature for doing work, but in place of caloric is a distinction between useful energy and non-useful energy. Useful energy is that which can be used to create change; non-useful energy is energy in a state of equilibrium that does not change except by outside influence. Two bricks in thermal equilibrium at the same temperature, for instance, are incapable of doing work by way of an exchange of heat from one brick to the other.

It is therefore possible to have a certain amount of energy in the form of heat at absolute temperature, say T_1. In theory, we can only harness all of the energy of a system if its temperature is reduced to absolute zero, as by a remarkably efficient machine of absolute zero temperature that is capable of harnessing it. Generally, however, systems are somewhere between absolute zero whereby the energy can only be harnessed by lowering it from T_1 to T_2 according to the relation

$$1 - \frac{T_2}{T_1}$$

Applicable to this relation is an absolute temperature scale, which Kelvin introduced after Joule suggested in a letter to Kelvin that it was possible to measure the difference from absolute zero. All heat energy is thus available if $T_2 = 0$; none is available if $T_2 = T_1$.

The relation here does not include latent or stored energy, as that of atomic energy. Clausius had already considered this aspect of the principle and went on to generalize the process in the form of an empirical law he named entropy, which is defined in various ways. Its general conditions are: entropy is a measure of the energy of an isolated system unable to do work; it does not decrease other than by increasing entropy of another system. A proportional amount of energy within the universe is thus never available to produce change. Whether this total proportion of non useable energy itself increases further depends on what is the ultimate capability of the universe.

For an example of decreasing entropy consider a laboratory having no outside influence except for gravity. Inside the laboratory a string keeps a rubber ball from falling. Eventually the string breaks to allow the ball to fall in converting potential energy as kinetic energy. Assuming the ball and floor to be nearly elastic, two forms of energy (potential and kinetic) alternate as the ball bounces, but the ball also encounters the friction, or viscosity, of the air while in motion, and the process tends to be inelastic. Even if there is no air, it is inelastic due to heat generated by the ball's impact with the floor. Thus, as the ball eventually comes to rest on the floor, kinetic energy converts into heat energy, as given for increasing the relative speed of the floor molecules that pass on the added motion to the outside matter they

heat up in turn. If the system is isolated such that it has no direct contact with another, then entropy is obtained by means of emitting radiation. By either way, the interaction ends in a state of equilibrium that is irreversible except for outside influence. Entropy is thus increased to a maximum until another part of the universe intervenes.

A quantity of heat, Q, is thus a determining factor of entropy in ratio to the absolute temperatures of the internal bodies of an isolated system, as the difference in temperatures of the bodies determines the amount of heat available for useful work. Thus, when a body at temperature T_1 surrenders heat Q to another body at temperature T_2, a change in entropy, ΔS, of the two bodies is

$$\Delta S = \frac{Q}{T_2} - \frac{Q}{T_1}$$

If a system performs work, then the amount of heat Q_1 lost at temperature T_1 will generally differ from an amount of heat Q_2 gained at temperature T_2, such that the change in entropy is according to the equation

$$\Delta S = \frac{Q_2}{T_2} - \frac{Q_1}{T_1} \geq 0$$

The result ΔS = 0 is called an adiabatic process that is efficient enough for entropy to be conserved.

Generally, the action between systems is such that energy is conserved, but its entropy is not conserved. An adiabatic process is thus a special case of nature. If the universe is infinite in extent, for instance, it could decrease entropy by way of mass condensing by gravity to create pressure and higher temperature to counter the increases in entropy from the work of individual systems. A finite expanding universe allows an increase in entropy, as for an eventual heat death of thermal equilibrium. Although the expansion rate is now interpreted as increasing due to increase in so-called dark energy, an adiabatic process of conserving entropy could still be in effect with regard to unobservable or dark energy needed for its decrease.

The adiabatic process, as given in a later chapter, was an integral part of the derivation of the quantum aspect of nature. The derivation related to an analysis of the temperature and pressure of a blackbody. Part of this analysis is a so-called Stefan-Boltzmann fourth power law according to the adiabatic process of thermodynamics. Although the derivation of this law pertains specifically to a blackbody radiation, there is a similarity regarding mass-energy density of the atomic structure. A proton is about 1836 times more massive than an electron, for instance, but it is also contained within a volume of space, as inside the nucleus of the hydrogen atom, that is about

1836 times less in radius than the rest of the volume of the atom containing the electron. The 1836 times greater mass inside a volume of space about 1836 cubed times smaller is a ratio of mass densities about 1836 to 1 to the fourth power.

A down to earth example of entropy is with regard to environmental concerns. Potential energy is stored within Earth as oil. Using it increases entropy, except this increase is countered by a decrease in entropy in the atmosphere, as the spent energy in the form of carbon monoxide results in greater absorbing of heat from the sun. However, the atmospheric work energy is less controllable, causing such havoc as hurricanes, draught and so forth. When potential energy inside Earth is used up, as resulting in more hazardous conditions of the atmosphere, rational solutions are needed to find out how to use solar energy in place of fossil fuels. Chemical engineers at the University of Washington, for instance, have discovered that light can charge a water battery. Why not? As light interacts with atoms to displace electrons, water pH is changed to differ from place to place such that cheep solar batteries of water could possibly support, at the least, more expensive solar panels of silicon.

FROM WAVE THEORY TO RELATIVITY

Theories of nature evolved from opposing views pertaining to how space is filled. By one, the internal nature of matter is comprised of indestructible atoms moving by way of a partial vacuum. By another, a primary substance fills all space as a plenum.

Belief in the plenum was popular from the time of Aristotle until the development of fundamental laws of motion. After Copernicus put forth his heliocentric view of the solar system, and Galileo and Newton put forth their mechanics, it became apparent Earth moves freely as though the space before it is empty. It was thus natural to assume space is only partially filled, as with tiny, indestructible atoms. However, such philosophers as Descartes proposed, to the contrary, that atoms are tiny vortices of swirling æther to only appear as though they move as particles through empty space.

Nowadays the majority of physicists consider æther as non-existent, or invalid, since it is invisible in theory and since physics confines itself to only what is observable, but it nonetheless has a long history in the development of theory, which wave action is an integral part of, as illustrated by the chain reaction below.

The illustration above depicts how momentum continues, as by either a medium or an empty space before it. If by the medium, the momentum is transferred to and from each iron ball by way of an impulse. There is thus an impulse of momentum carried from one end of the row to the other end when the former is struck by another ball. In this case, the ball at the other end continues the momentum as seemingly relative motion of a particle.

The particle description is simpler, but the wave action is still helpful for understanding the true complexity of nature. Newton, for instance, was

unable to explain the cause of gravity by way of contiguous action. He thus described it according to an "action at a distance principle". Although other physicists have attempted to explain the direct cause of gravity, none have been successful for centuries to come. Wave theory, on the other hand, can be more extensive in its approach. Waves, for instance, can superimpose to negate their relative effects, as to explain gravitational action at a distance in analogy to the illustration of the iron balls.

Wave action, however, is extremely complex with regard to the various ways it can occur, depending on the nature of the wave producing medium. Sound waves, for instance, propagate longitudinal action whereas transverse action is more typical of the wave property of light. Most waves are periodic in nature, as for allowing any periodic motion of a particle to be described in accordance with a wave equation, but surface waves of the ocean vary in their periodicity with regard to a change in water depth.

Wave action is insightful for anyone able to grasp its complexity, but such complexity is here avoided in favor of restricting it to a history of light.

Light and Wave Theory

Waves are obvious events, such as surface ripples on a pond that are created by some sort of disturbance. In relating the wave action, Aristotle proposed light occurs from a wave-like disturbance of air. However, as far as is known, there was no constructive wave theory of light until 1678 when Christian Huygens (1629-1695) proposed his.

Huygens offered a principle that wave envelopes are created anew at every point in space that a wave impinges on. Their creation spreads in all directions, but supposedly (as without any explanation by Huygens) waves created back towards the center where the original disturbance occurred are obliterated by the overlapping of continual creation, as to restore a state of equilibrium. Only the outer envelopes continue to spread from the center.

The theory has been criticized for its lack of explaining the obliteration effect, but Huygens likely had in mind that the wave action is in compliance with the law of conservation of momentum. He offered the mathematical form of centripetal force before Newton did. With such understanding of the laws of motion, he could have perceived the inner obliteration of wave action as the mutual cancellation of equal momenta in opposite directions, whereas the advancing waves merely carry momenta forward. In analogy to the iron balls in a row, elastic space allows an excess amount of momentum to move forward while the obliteration of waves is a recycling process for maintaining a state of equilibrium for the creation of more waves.

Huygens was able to explain double refraction in accordance with his theory. However, reflection and refraction were more simply explained in accordance with a particle theory of light.

The law of refraction was accurately explained in a manuscript by Ibn Sahl (940-1000) of Bagdad as early as 984. In 1021, it became promoted in a treatise on optics by Alhazen (965-1014), who viewed light as consisting of rays of particles. It was first formulated in Europe by Willebrord Snellius (1560-1626). Descartes later introduced the sine function for the ratio of angles, but it is now commonly referred to as Snell's Law.

The direction of a stick submerging into water appears to change, but the change is an optical illusion. Instead of the stick changing direction, the light from it has changed directions twice by entering into and leaving from a denser medium, as refracted. Whereas reflection is simpler in that it equals the angle of incidence, refraction entails the change in speed of the wave entering into a different medium, such that the ratio of angles of incidence θ_1 and refraction θ_2 equate with the ratio of speeds v_1 and v_2, and with the inverse ratio of refractive indexes n_1 and n_2 of the two mediums:

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{n_2}{n_1}$$

Huygens used his wave theory to explain double refraction of light, as discovered by Rasmus Bartholin (1625-1698) in 1669 to occur in a calcite crystal called Iceland spur. In double refraction, the light rays split into two directions, one ordinary and the other extraordinary. The ordinary direction complies with the law of refraction, whereas the extraordinary direction is in non-compliance with the law. An explanation of this non-compliance by Huygens' theory is allowed insofar as ripples of the medium spread waves in all directions. However, a more complete explanation was forthcoming with the development of wave theory to include properties of interference and transverse vibrations.

The corpuscular theory of light remained in favor until Thomas Young (1773-1829) proposed a principle of interference. Leonardo da Vinci (1452-1529) had observed water waves can cross paths without obstructing each others' movements. Young applied this wave effect to light waves, but with the crossing of waves having additional effects of interference. He surmised that the waves superimposing combine to either increase or decrease their effect depending on the degree they are either in or out of phase. If waves overlap in phase, then the intensity of light appearing on a smooth surface becomes enhanced. If the waves overlap in opposite phase, then their effect is canceled for a dark spot to appear. Thus, in some cases, the overlapping creates more light; in others, it annihilates light.

Young introduced the principle of interference to explain light and dark fringes in diffraction patterns. Francesco Maria Grimaldi (1618-1663) had discovered sunlight spreads abnormally when it passes through a small hole. Young drilled two holes for an experiment, and he found light and

dark fringes occurred when they otherwise would not if only one hole was drilled. The fringe pattern is explained as the diffraction patterns of two rays of light overlapping in and out of phase. Where they overlap in phase, light intensity increases more than the sum intensities of each ray before they overlapped; where they overlap in opposite phase, no light appears.

Some experiments produce no interference, which is now explained as light emitted from the source as relatively incoherent. Since light waves are extremely rapid, and since trains of them are relatively short, it is possible to detect two or more rays superimposing only in particular circumstances. It occurs in Young's experiment by a drilling of holes close together. Another method is to split a light ray into two components, as by partial reflection. The split parts reflect in different paths of slightly different distances for them not to rejoin in their original state; they superimpose instead into a slightly different state.

Transverse Waves

Young was able to explain nearly all light effects except polarization, the condition whereby transverse motion determines a particular direction for either the reflection or refraction of waves. Etienne Louis Malus (1775-1812) discovered in 1808 that either reflection or refraction can produce polarization. Young was not able to explain it because his medium for light waves compared to the propagation of sound through air as longitudinal waves of rarefaction and condensation of the air medium moving to-and-fro in the direction of propagation. This process does not explain a varying intensity by which light either absorbs or reflects according to the angle of incidence.

Young suggested in 1817 that the waves need to contain transverse components in order to explain the polarization effect. Augustin Fresnel (1788-1827), who was unaware of this suggestion, formulated a theory of optics in 1818 that explained polarization as transverse waves. His theory includes both Young's principle of interference and the principle set forth by Huygens of continuous waves spreading from all points of contact with space. However, the transverse wave led to another enigma inasmuch as the transverse wave does not normally occur in a three-dimensional solid state. A rigid medium for three-dimensional space seemed to be too much of an obstacle to explain how the planets and other mass objects move as freely through it as they appear to do.

The Elastic Medium

In investigating properties of the elastic medium, Claude Louis Navier (1785-1836) assumed objects are of extremely minute and compact particles whereby attractive and repulsive forces counteract in maintaining a state of

equilibrium. The restoring force is analogous to a liquid reacting according to the motion of the particles. The solid state is conditional to the distance of separation between particles.

Navier's theory was elaborated on by Augustive-Louis Cauchy (1789-1857) with a law of elasticity that Robert Hook (1635-1703) had proposed. Accordingly, the stretching of an elastic body is proportional to the force applied to it.

Cauchy interpreted Navier's theory as setting up a condition of strain. Physicists call the mathematical formulation of this condition a tensor in relation to a more complex vector quantity in applying to variable forces of higher order. A vector refers to a quantity having both particular magnitude and direction. The speed of a current, for instance, displaces the path of a boat crossing a river at a given speed. A vector speed and direction is the boat moving in one direction and the current moving in another. A tensor could include an increase in the speed of the current, say, due to it nearing a waterfall.

Cauchy's mathematical results were consistent with those of Navier's homogeneous media, but more than one elastic constant of proportionality is needed for isotropic media. Whereas a homogeneous medium is the same everywhere, an isotropic one is the same only in directions, as it can vary in distance and other aspects. The media is necessarily isotropic in the case of Cauchy's results in allowing more than one kind of wave (as transverse and longitudinal) to propagate through it.

The equations of elastic solids were incompatible with optics insofar as they allowed for longitudinal vibrations as well as transverse ones. Cauchy overcame this incompatibility by considering the æther as labile, as able to also change to a negative compressibility. This negative compression allows the æther to react differently to different kinds of waves and even to allow the longitudinal velocity to be zero.

George Green (1793-1841) investigated Cauchy's results, and he found them to be inconsistent with conservation of kinetic energy. They were also shown by Simeon Denis Poisson (1781-1840) and Franz Ernst Neumann (1798-1893) as inconsistent with a wave theory developed more completely by Green.

Electromagnetic Rotation

As to how the planets and other objects move so easily through æther of such solidity, ideas came forth. Gabriel Stokes (1819-1903) suggested the effect is relative. The æther relates to the slow moving planets as a rarefied fluid, or jelly, but to the extremely rapid vibrations of light as a solid. James Mac Cullagh (1809-1847) proposed ethereal vortices or atoms do not resist a displacement resulting in distortion of the medium; they change in their

state of rotations instead. This process is of a transverse nature that allows atoms to move freely through the æther, as only their rotations are subject to luminous effect.

With these two ideas combined, matter moves through æther without resistance, as if sinking into a jelly, whereas light occurs as changes in the rotational states of atomic like vortices. As rotation allows movement in the plenum, there emerges an infinitely complex variation of rotations to allow unlimited effects of light, electricity and magnetism as particular aspects of wave action.

Such speculative ideas preceded empirical discoveries. In 1820, Hans Christian Oersted (1777-1851) tested the effects of a magnetic needle near an electric current induced in a wire from a battery. He discovered the wire deflected the needle, as for a connection between electricity and magnetism. Francois Arago (1786-1853) then discovered an electric current magnetizes iron. Soon thereafter, Andre-Marie Ampere (1775-1836) demonstrated that electric currents affect each other similar to the attraction and repulsion of magnetic poles. Electric currents repel each other when flowing in opposite directions; they attract each other when flowing in the same direction.

In 1831, Michael Faraday (1791-1867) discovered change in a magnetic field induces an electric current in a wire. The aid of mechanical energy in rotating the poles of a magnet thus produces an electric current in a coiled wire that further produces additional magnetic effect. As an electric current produces an electromagnet, the electromagnet, in turn, produces additional current, as by alternating the poles of the electromagnet near to the wire. The result is electromagnetic induction, as to how the generator is able to transform mechanical work into electricity.

A law to equate an electrical current to a magnetic field was developed by Jean-Baptiste Biot (1774-1862) and Felix Savart (1791-1841), and also by Pierre Simon Laplace (1749-1827). A significant part of the law is a constant of proportionality c equating a unit of electric charge e per time t passing through a unit length d of a section of a wire in proportion to the magnetic pole strength p, as $cp/e = d/t$. The pole strength p of the magnetic field is of the same dimensions as a unit of charge e of an electric field. They cancel each other out in the equation for c to be identified as a velocity: $v = d/t$.

Wilhelm Eduard Weber (1804-1891) and Rudolph H. A. Kohlrausch (1809-1858) ascertained in 1836 the value of c is the same as light speed, namely about 3×10^{10} centimeters per second.

The constant of proportionality c having the dimensions of a velocity was significant for the formulation of an electromagnetic theory. Ampere had believed magnets are really electromagnets induced by electric currents within molecules of matter instead of in wires. However, Faraday believed magnetic currents, or, as in his way of thinking, "lines of force" exist in a

seemingly empty space whereby changes occurring in electromagnetic fields take time, and the propagation of their effect is the propagation of light.

Faraday did not formulate a mathematical theory. His ideas along with others were included in a theory of electromagnetism formulated by James Clerk Maxwell's (1831-1879). According to it, electricity need not conduct through either wire or molecules of matter, as it can propagate through the continuum of space as provided by the presence of an electromagnetic field. Simply put, the displacement of electric current produces an electric field that induces a magnetic field that, in turn, induces another electric field, etc. An open field creation thus progresses at light speed as the electromagnetic spectrum.

Advancing Theory

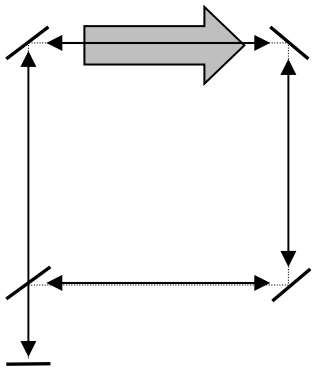
A verification of Maxwell's theory of electromagnetism came in 1888 when Henrock Rudolf Hertz (1857-1894) produced electromagnetic waves in showing that they interfere with themselves, and he even measured their wavelengths as fringes produced on a screen.

The next task became to determine the state of the æther in relation to matter. For instance, if the speed c is constant through the æther, it is also consequential whether æther itself is in motion, as either existing in a state independent of matter or influenced by the presence of matter.

Three possibilities were considered: 1) no æther is carried by matter; 2) matter only partly carries æther; and 3) matter carries all æther within the confinement of its path. Hertz adopted the third hypothesis, which Stokes had already presented in 1845, but it was inconsistent with the experimental results. More consistent with the facts was a partial drag hypothesis, which had been proposed by Fresnel. Even closer to a theory consistent with all the facts was one offered by Hendrick Antoon Lorentz (1853-1928), which assumes æther is a constant state independent of matter such that it can be designated as a particular state of absolute rest. The assumption is incorrect, but its rebuttal led to the special relativity principle, which can explain all experimental results by assuming the properties of matter are altered while moving through the æther. Clocks, for instance, are slower and the length of matter in the direction of motion is shorter.

A particular experiment of significance at the time, as illustrated below, was one suggested by Francis Arago (1786-1856) indicating matter drags the æther. As light rays are split by a partially coated silver mirror, other mirrors direct the split parts to pass in opposite directions through a glass tube of running water. In result, the rays moving in the same direction as the water arrive back sooner than the rays moving in an opposite direction. However, the increased speed of some light and the decreased speed of other light are

only equal to a fraction of the water speed, as in agreement with Fresnel's partial drag hypothesis.



This experiment supported Fresnel's partial drag hypothesis, but it was not able to explain another experiment by Edward Williams Morley (1838-1923) and Albert Abraham Michelson (1852-1931) in 1881, which did not include the running water. If æther is either dragged or partially dragged by matter, then the slight shift in fringes of the wave pattern on a screen by this similar experiment should indicate a change in direction of Earth as it rotates on its axis and revolves around the sun. To the contrary, however, no appreciable change was observed to occur.

Explaining Experiment

The result of one experiment was consistent with Fresnel's partial drag hypothesis. Another experiment favored Stokes' complete drag hypothesis. What was needed was a theory able to explain the results of all experiments in a consistent manner. A near candidate at the time was Lorentz's electron theory.

Lorentz had theorized that electromagnetic fields consist of minute particles that bond together by their mutual attraction from having opposite charge. They are thus in a mutual state of vibrant equilibrium. Such a state affects light propagating through it. Since an electromagnetic field produces light, the state of the field is changed as well. As the electromagnetic waves of light interfere with the equilibrium state of charged particles, the field reacts to change vibrant states of charged particles. The resulting effect is that there is an increase in inertia of matter as it moves through the æther, as to vibrate at a slower rate and as having more external momentum.

The vibrations of matter also replace the æther as a light medium, as typical of water or glass changing the direction and speed of light, but light

propagating through a material medium of the electronic state differs from that of the ethereal medium. The material medium varies in its relation to variable light whereas the ethereal medium is the same for all light. The different size light waves move at different rates depending on the relative density of the material medium. The light moving in the same direction as the water is therefore faster than if moving contrary to it. Matter becoming the medium of light propagation instead of dragging it explains the result of the Arago experiment. It did not, however, explain the Michelson-Morley null results.

To explain the null results of experiment, Lorentz assumed that matter moving through æther is squashed in the direction of relative motion. The arm of the apparatus in the relative direction of motion being contracted results in light moving the same relative distance, as part of the apparatus, in any direction regardless of how they move relative to the æther.

Although contraction of length is sufficient by itself to explain the null results of the Michelson-Morley experiment, Lorentz went a step further in defining a "local time" in assuming clocks are similarly affected by moving through æther. Hence, a time of propagation is the same as if the apparatus is at absolute rest with the æther, suggesting the state of absolute rest in the æther is not ascertainable by means of the Michelson-Morley experiment.

Jules Henri Poincare (1854-1912) urged Lorentz in 1900 to generalize his theory to comply with the principle of relativity wherefore one motion of mass is merely relative to the motion of other mass. Lorentz did provide transformation equations to this effect, but he maintained it might still be possible to detect absolute rest. Meanwhile, Einstein independently derived the Lorentz transformations in a manner free of all preconceived notions pertaining to the æther.

Lorentz and Einstein's Explanations

Woldemar Voight (1850-1919) had derived these same transformation equations in 1887 to describe a rigid medium of light as a non-compressible fluid. Voight considered the theories of Cauchy, Neumann and others in view of the Doppler Effect propounded by Christian Doppler (1803-1853). By it, sound waves or light waves either expand or contract depending on the relative direction of motion of the observer and the source of emission. However, neither Lorentz nor Voight applied the transformation equations more generally to the laws of mechanics. Einstein did. As a consequence of it and the development of quantum physics, the æther as a methodological part of scientific theory became discarded.

In reformulating the principle of relative motion, Einstein emphasized the æther is unnecessary for formulating theory. He demonstrated this claim in 1905 with his formulation of special relativity theory for the unification

of electrodynamics and mechanics, as it only postulated the constant speed of light as an empirical fact of nature with no reference to the æther or anything else for its possible explanation.

Einstein did suggest the æther could be used for understanding theory, as just not for its formulation, but other physicists did not agree the æther should be retained. After physicists discovered light and matter each have dualistic particle-like and wave-like properties, leading physicists such as Bohr, Born and Heisenberg reinterpreted the so-called wave equations as probability equations, as for determining the probable location, time, energy and momentum for a particle effect to occur.

SPACETIME RELATIVITY

Einstein formulated special relativity (SRT) according to two postulates: 1) the speed of light is constant in a vacuum relative to the observer regardless of what the velocity of the observer is relative to any other; 2) the laws of physics are the same in all inertial reference frames.

The second postulate is also called the principle of covariance. Light speed is covariant, but it is unique as well in that its speed in vacuum space is the same in contrast to the variable speed of matter.

How these postulates modify Galilean relativity according to Newton's absolute space and absolute time according to constant light speed and the relativity of spacetime begins with the null result of the Michelson-Morley experiment. It continues with derivations of Lorentz Transformations and so forth, as explained in view of the modification of Galilean relativity and how observation of absolute rest is nullified.

The Michelson-Morley Experiment

The Michelson-Morley experiment attempted to measure light speed in relation to the æther. If the æther is representative of a state of absolute rest, and if all light waves propagate at the same speed through the æther, then light speed should vary as Earth's motion varies through the æther in various directions in orbit around the sun. However, no significant variation in light speed was ascertained by this experiment, or any other, such as not to be in compliance with the principle of relativity.

According to the nature of this experiment, light speed is measured as a to-there-and-back event. A silver-coated lens is positioned at a 45-degree angle to the incident light in splitting it into separate rays. One ray passes through a lens in the same direction while the other ray reflects at a right angle. Two more lenses then reflect the light rays back to the silver coated lens to pass through it and superimpose onto a screen.

What physicists expected from this arrangement is the total distance of each split ray differs due to the perpendicular lengths of the apparatus not being precisely equal. What actually appears on the screen is an interference pattern of light and dark fringes (as are predicted of superimposed waves according to wave theory). An appreciable amount of change to verify the change in the speed of light is what was not observed.

To explain the null results, Lorentz first assumed the length s_x of the apparatus contracts in the direction of relative motion by the factor

$$\alpha = \sqrt{1 - \beta^2}$$

The symbol β represents v/c, as the relative direction and speed of matter divided by light speed. Perpendicular lengths s_x and s_y are considered equal:

$$s_x = s_y = s$$

Each arm of the apparatus compares as equal to a proper length denoted as s such that, if the apparatus is theoretically at absolute rest, the respective times it takes light to move respective distances there and back is according to the equations

$$2t_x = t_{x1} + t_{x2} = \frac{s}{c} + \frac{s}{c} = \frac{2s}{c}$$

$$2t_y = t_{y1} + t_{y2} = \frac{s}{c} + \frac{s}{c} = \frac{2s}{c}$$

In these equations, t_{x1} and t_{y1} are the respective times there, and t_{x2} and t_{y2} are the respective times back.

What if the apparatus moves at velocity v in the x direction relative to absolute rest?

According to Galilean relativity and the premise light speed is invariant relative to the æther, the times for light to move respective distances s_x and s_y vary (if no relativistic contraction of length in the direction of relative motion occurs). The differences in light speed and the apparatus are thus c – v in the direction of relative motion and c + v in the opposite direction of relative motion. Total time of the to-and-from propagation along the x-axis should be

$$2t'_x = t'_{x1} + t'_{x2} = \frac{s}{c-v} + \frac{s}{c+v}$$

$$= \frac{s(c+v)}{(c-v)(c+v)} + \frac{s(c-v)}{(c+v)(c-v)} = \frac{sc+sv+sc-sv}{(c-v)(c+v)}$$

$$= \frac{2sc}{c^2-v^2} = \frac{2sc}{c^2\left(1-\frac{v^2}{c^2}\right)} = \frac{2s}{c(1-\beta^2)} = \frac{2s}{c\alpha^2}$$

This time is comparable to $2t_x = 2s/c$, which is as if the apparatus were at absolute rest. If the arm of the apparatus instead contracts in the direction of relative motion by the factor α, then the difference from that of absolute rest is only by the factor 1/α.

Similarly, the total time it takes light to propagate in the perpendicular direction of relative motion, say during time $2t'_y$, can be determined. The actual path of light is according to two directions: 1) the direction along the arm of the apparatus that is perpendicular to the direction of relative motion; and 2) the direction of relative motion in keeping pace with the apparatus. The actual distance is along a hypotenuse of the right triangle with respect to distance moved of those two other perpendicular directions. Hence

$$\left(ct'_y\right)^2 = s^2 + \left(vt'_y\right)^2$$

$$s^2 = \left(ct'_y\right)^2 - \left(vt'_y\right)^2$$

$$s^2 = \left(t'_y\right)^2(c^2 - v^2)$$

$$\left(t'_y\right)^2 = \frac{s^2}{c^2-v^2} = \frac{s^2}{c^2(1-\beta^2)}$$

$$t'_y = \frac{s}{c\alpha}$$

The time light moves to-and-from in the perpendicular direction of relative motion is

$$2t'_y = \frac{2s}{c\alpha}$$

It is the same with respect to the direction of relative motion if the arms of the apparatus in the direction of relative motion contract by the factor α.

Because light moves at the same time, speed and distance along both arms of the apparatus, there are no differences observed of a shift in the pattern of fringes. Although this explains the null result of experiment, it only requires the apparatus to contract in the direction of relative motion; it does not require clocks to retard as well. However, it is just another step to

determine them as relatively retarded according to relative motion through the æther, as to complete the analysis in view that absolute rest is invisibly non-discernible.

If clocks are slower by the factor 1/α, durations of events are shorter by the factor α. Hence

$$2t'_x\alpha = 2t'_y\alpha = \frac{2s}{c\alpha}\alpha = \frac{2s}{c} = 2t_x = 2\mathrm{t_y}$$

Absolute rest is thus invisible with regard to the there and back measure of light speed.

This mathematical result constitutes a general explanation of constant light speed. What follows from it are more intricate explanations in relating such principles as covariance and simultaneity. With regard to the relativity of simultaneity, for instance, it is not possible to measure light speed, in view of absolute rest, by timing signals from one place to another by a clock that determines the time of an emission as synchronous with a clock that determines its time of reception. The synchronization of clocks by means of comparing signals invalidates the measure of light speed from signals emitted according to these clocks. Moreover, to confirm the two clocks are synchronous by direct means requires a transportation of one clock to the location of the other, as to involve relative motion that retards clocks. Since the exact speed of the clock relative to absolute rest is an unknown, the amount of retardation of the clock in relative motion is unknown as well. To be sure, mathematical analysis is to verify the relativity of constant light speed, as covariant, is maintained.

Simultaneity

Even though Einstein postulated constant light speed as fact without explanation, his principle of simultaneity helps explain it. Because Observer B's clock in relative motion is slow, it is not simultaneous with the clock of Observer A relatively at rest. By the principle of covariance, however, A and B perceives events the same, such that B is also regarded as relatively at rest. The simultaneity of events is thus the same for both observers.

Consider B moves away from A at velocity v to a distance x after time t according to A's clock. The task is to show B's perception of time is the same as that of A's. At distance x, it takes time x/c for light from B to move to A. The time for A to see B move the distance x is thus x/v + x/c. Since the coordinate lengths of B are contracted in the direction of motion by the factor α, and since duration of events are also shorter by the factor α, as timed by B's slower clock, and because the difference in B's velocity from that of light is c – v in relation to A being relatively at rest, the equality of A and B's timing of the event is

$$\frac{t'}{t} = \frac{\frac{x\alpha^2}{v}+\frac{x\alpha^2}{c-v}}{\frac{x}{v}+\frac{x}{c}} = \frac{\frac{\alpha^2}{v}+\frac{\alpha^2}{c-v}}{\frac{1}{v}+\frac{1}{c}} = \frac{\frac{\alpha^2(c-v)+\alpha^2 v}{v(c-v)}}{\frac{c+v}{vc}} =$$

$$\frac{\alpha^2 vc(c-v)+\alpha^2 v^2 c}{v(c-v)(c+v)} = \frac{\alpha^2 c(c-v)+\alpha^2 vc}{c^2-v^2} =$$

$$\frac{\alpha^2 c(c-v)+\alpha^2 vc}{c^2\alpha^2} = \frac{c-v+v}{c} = 1$$

The relativity of simultaneity is thus covariant, at least with respect to different speeds and locations of only two observers.

Lorentz Transformations

Transformation equations transform distance and time coordinates of observers in relative motion to the coordinates of the other observer. Let x, y, z, t be the spacetime coordinates of Observer A relatively at rest, and let corresponding coordinates of Observer B relatively in motion be x', y', z', t'. Respective origins O and O' of the two coordinate systems overlap at time t = t' = 0, such that the time and distance of an event in coordinate system B, as perceived by Observer B, is transformed in view of Observer A's perception, and vice versa.

First consider a transformation of coordinates as in view of Galilean relativity with regard to system B is at velocity v relative to system A. Let the origins of respective observers A and B be at the same place during the instant $t_0 = 0$. At this instant the coordinate distance s that system B moves at velocity v becomes shorter during time t by the amount s* = vt. Hence

$$s^* = s - vt$$

S* is the coordinate distance vt of Observer B from Observer A at time t. The result only assumes the measures of distance and time are relatively the same for all observers.

The event could be in any direction of relative motion. To describe it according to Galilean relativity, where clocks and distance coordinates are not affected by relative motion, three-dimensional-perpendicular coordinate systems are established. Coordinate system B has perpendicular coordinates from origin O at time t are x, y, z, t for both A and B. For comparison of relativistic values of clocks and measuring rods affected by relative motion, they are x', y', z', t' for B and x, y, z, t for A relatively at rest.

The coordinate lengths y' and z' are perpendicular to the direction of relative motion and are not contracted by it. Hence, y' = y and z' = z. In the

manner of explaining the null results of the Michelson-Morley experiment the distance light actually moves perpendicular to the direction of relative motion is increased by the same mathematical factor the duration of a clock in relative motion is increased. The extended time it takes light to propagate farther is negated by the slower clock.

In contrast, the x and x' directions of relative motion moving relative to each other in opposite directions are consequential to how distances are determined by each observer. Since Observer B's clock is slow, B moves an extended duration and an extended distance such that a comparison of the Lorentz transformation to the Galilean one is

$$x' = \frac{x - vt}{\sqrt{1-\beta^2}}$$

As for the transformation of time coordinate, distances coordinates convert into time coordinates and vice versa. With constant light speed as a measure of distance, the respective times t and t' can be replaced with x/c and x'/c. Substituting ct' for x', ct for x, and x/c for t obtains

$$t' = \frac{t - \frac{vx}{c^2}}{\sqrt{1-\beta^2}}$$

This is the Lorentz transformation that transforms the coordinate time t' of system B in view of system A.

Covariance

These transformation equations are here derived in view of how an observer at absolute rest interprets events perceived by observers in relative motion. They have not yet been related to how observers in relative motion determine events considered as relatively at rest. A more general application of the equations is thus needed in view of the principle of covariance, such that absolute rest is a state that cannot be empirically determined.

Covariance means the laws of physics are the same for all systems of reference. Constant light speed is thus covariant, but it is a unique property that differs from relative motion of matter whereas covariance applies to all physical events.

Covariance further means the perceptions of observers A and B are the same with regard to A or B being relatively at rest and the other moving at speed v. Since relative motion affects lengths and clocks, it is not obvious their speeds are the same relative to each other, but covariance of relative motion is easily verified mathematically.

Consider Observers A as at absolute rest wherefore Observer A sees Observer B move towards Observer A at velocity v the distance from x_1 to x_0 during time $t_1 - t_0$. The event includes a difference in time it takes light to move the difference in distance of positions x_1 and $x_0 = 0$. The time t_a of Observer A seeing Observer B moving the distance $x_2 - x_1$ is

$$t_a = \frac{x_1 - x_0}{v} - \frac{x_1 - x_0}{c}$$

Since the clock of Observer B is slow by the factor $1/\alpha$, since Observer B approaches the oncoming light at velocity v, and since coordinate lengths of Observer B are relatively shorter by the factor α, the duration of Observer B seeing Observer A move along length $(x_1 - x_o)\alpha$, as according to observer B's clock, is

$$t_b = \frac{(x_1 - x_o)\alpha^2}{v} - \frac{(x_1 - x_o)\alpha^2}{c+v}$$

The task is to show $t_a = t_b$:

$$\frac{x_1 - x_o}{v} - \frac{x_1 - x_o}{c} = \frac{(x_1 - x_o)\alpha^2}{v} - \frac{(x_1 - x_o)\alpha^2}{c+v}$$

$$\frac{1}{v} - \frac{1}{c} = \frac{\alpha^2}{v} - \frac{\alpha^2}{c+v}$$

$$c(c+v) - v(c+v) = c\alpha^2(c+v) - vc\alpha^2$$

$$c^2 + vc - vc - v^2 = c^2\alpha^2 + vc\alpha^2 - vc\alpha^2$$

$$c^2 - v^2 = c^2\alpha^2$$

$$c^2\left(1 - \frac{v^2}{c^2}\right) = c^2\alpha^2$$

Since $\alpha^2 = (1 - v^2/c^2)$, the equality $t_a = t_b$ is confirmed such that observers A and B perceive relative motion the same regardless if either Observer A or Observer B is at absolute rest.

Illustrating covariance more generally is by way of solving for x and t in the Lorentz transformations. Hence

$$x' = \frac{x - vt}{\alpha} \qquad t' = \frac{t - \frac{vx}{c^2}}{\alpha}$$

$$x'\alpha = x - vt \qquad t'\alpha = t - \frac{vx}{c^2}$$

$$x = x'\alpha + vt \qquad t = t'\alpha + \frac{vx}{c^2}$$

$$x = x'\alpha + v\left(t'\alpha + \frac{vx}{c^2}\right) \qquad t = t'\alpha + \frac{v(x'\alpha + vt)}{c^2}$$

$$x = x'\alpha + vt'\alpha + \frac{v^2x}{c^2} \qquad t = t'\alpha + \frac{vx'\alpha}{c^2} + \frac{v^2t}{c^2}$$

$$x - \frac{v^2x}{c^2} = x'\alpha + vt'\alpha \qquad t - \frac{v^2t}{c^2} = t'\alpha + \frac{vx'\alpha}{c^2}$$

$$x\left(1 - \frac{v^2}{c^2}\right) = \alpha(x' + vt') \qquad t\left(1 - \frac{v^2}{c^2}\right) = \alpha\left(t' + \frac{vx'}{c^2}\right)$$

$$x = \frac{x' + vt'}{\alpha} \qquad t = \frac{t' + \frac{vx'}{c^2}}{\alpha}$$

The comparative forms of the transformations are the same except for the direction of motion. The observer moves at velocity v relative to the other and the other moves at velocity –v. All motion is thus covariant.

Adding Velocities

Since clocks in relative motion differ, it is not obvious how observers in relative motion determine other velocities, as their calculation requires a theorem for adding velocities. To derive it, consider inertial systems A, B and C. Consider A as relatively at rest, B as moving at velocity v_1 relative to A, and C as moving at velocity v_2 relative to B. The task is to determine the velocity v_{12} of C relative to A along the x-axis.

In relating coordinates of B to those of A, velocity v_2 becomes

$$v_2 = \frac{x'}{t'} = \frac{[x - v_1 t]\sqrt{1 - \frac{v_1^2}{c^2}}}{\left[t - \frac{v_1 x}{c^2}\right]\sqrt{1 - \frac{v_1^2}{c^2}}} = \frac{x - v_1 t}{t - \frac{v_1 x}{c^2}}$$

Multiplying the first and last sides of the equation by $t - v_1x/c^2$ obtains

$$v_2\left(t - \frac{v_1 x}{c^2}\right) = x - v_1 t$$

$$v_2 t - \frac{v_1 v_2 x}{c^2} = x - v_1 t$$

Adding v_1v_2x/c^2 and v_1t to both sides of the equation obtains

$$v_1t + v_2t = x + \frac{v_1v_2x}{c^2}$$

$$t(v_1 + v_2) = x\left(1 + \frac{v_1v_2}{c^2}\right)$$

Finally, dividing both sides of the equation by t and $1 + v_1v_2/c^2$ obtains

$$\frac{v_1+v_2}{1+\frac{v_1v_2}{c^2}} = \frac{x}{t} = v_{12}$$

This equality represents velocity of C in relation to the coordinate system A.

The formula above is for comparing velocities in the same direction of motion. It is possible to derive a formula for systems moving perpendicular to each other as well. Consider A is relatively at rest, B as moving along the x-axis at velocity v_1, and D as moving along the y'-axis at velocity v_3. What is to be determined is the velocity of D relative to A.

In relating coordinates of B to those of A, velocity v_3 becomes

$$v_3 = \frac{y'}{t'} = \frac{y\sqrt{1-\frac{v_1^2}{c^2}}}{t-\frac{v_1x}{c^2}} = \frac{y\sqrt{1-\frac{v_1^2}{c^2}}}{t\left(1-\frac{v_1x}{tc^2}\right)}$$

Multiplying by $(1 - v_1x/tc^2)$ and dividing by the square root of $(1 - v_1^2/c^2)$, the left and right sides of the equation become

$$\frac{v_3\left(1-\frac{v_1x}{tc^2}\right)}{\sqrt{1-\frac{v_1^2}{c^2}}} = \frac{y}{t}$$

Since $x/t = v_1$, y/t becomes

$$\frac{y}{t} = \frac{v_3\left(1-\frac{v_1x}{tc^2}\right)}{\sqrt{1-\frac{v_1^2}{c^2}}} = \frac{v_3\left(1-\frac{v_1^2}{c^2}\right)}{\sqrt{1-\frac{v_1^2}{c^2}}} = v_3\sqrt{1-\frac{v_1^2}{c^2}}$$

This result is only of D moving along the y-axis relative to A. The velocity of D in the actual direction of the xy-plane has not yet been determined. To determine it, the Pythagorean Theorem applies with regard to the speeds in perpendicular directions. The result is

$$v_{13} = \sqrt{\frac{y^2}{t^2} + v_1^2} = \sqrt{v_3^2\left(1 - \frac{v_1^2}{c^2}\right) + v_1^2} = \sqrt{v_3^2\alpha_1^2 + v_1^2}$$

The velocity v_{13} is that of system D relative to system A.

The derivation of these equations for adding velocities is conditional to the assumption light speed is invariable for all observers, and they are to be consistent in showing light speed added to light speed, or added to any velocity, is still light speed c. To confirm:

$$c_{cc} = \frac{c+c}{1+\frac{cc}{c^2}} = \frac{2c}{1+1} = c$$

$$v_{12} = \frac{v_1+c}{1+\frac{v_1 c}{c^2}} = \frac{v_1+c}{1+\frac{v_1}{c}} = \frac{c(v_1+c)}{c+v_1} = c$$

$$v_{12} = \frac{c+v_2}{1+\frac{cv_2}{c^2}} = \frac{c+v_2}{1+\frac{v_2}{c}} = \frac{c(c+v_2)}{c+v_2} = c$$

$$v_{13} = \sqrt{v_3^2\left(1 - \frac{c^2}{c^2}\right) + c^2} = c$$

$$v_{13} = \sqrt{c^2\left(1 - \frac{v_1^2}{c^2}\right) + v_1^2} = \sqrt{c^2 - v_1^2 + v_1^2} = c$$

Light speed is thus the same in all inertial systems according to the addition of velocities formulas.

The Clock Paradox

Observers A and B in relative motion time each other's clock as slow. However, if B moves away from A, reverses direction and returns to A, then B's clock is found by direct comparison to be the slower one. This is the well-known clock paradox. It is conditional to covariance inasmuch as there is no distinction of absolute rest from relative motion. Both clocks are perceived slow relative to the other in relative motion, but only one of them is slow by direct comparison.

The paradox is explainable because the event is not symmetrical. The traveling observer changes direction; the stay at home observer does not. In order to show the clock paradox does not contradict theory, it is thus only necessary to show how Observer A's clock is slow if Observer A accelerates instead of Observer B. Instead of Observer B changing direction to return to Observer A, A merely accelerates in catching up with B. The events are symmetrical inasmuch as B moving away from A at velocity v uses more

force to become relatively at rest with system A, and uses more force to return to A at velocity –v, compares with A using force to become relatively at rest with system B, and using more force to move at velocity v_{12} in order to catch up with B.

To verify, consider Observer B is moving along the x-axis relative to Observer A at velocity v before changing direction along the x-axis at time T to move at velocity v instead of –v. With regard to A as at absolute rest, wherefore B moves relative to A, the comparison of time recorded by A's and B's clocks during the trip is

$$2T' = \frac{2T}{\alpha}$$

This longer time results from B moving an extended distance because of a slower clock.

The determination of time for the previous event is simple. However, for the event of A being relatively at rest and then moving to catch up with B, A's clock keeps two different rates while B's clock remains the same. By the addition of velocities theorem, a change in velocity is not simply from v to 2v; instead, it is from v to v_{12}, which involves a corresponding change in rate of clocks. This condition is thus more complex than the previous one.

The task is nonetheless to determine the total time for A to catch up with B is the same as before, namely $2T/\alpha$. In perspective, what is to be determined is

$$T + T'' = \frac{2T}{\alpha^2} = \frac{2T'}{\alpha}$$

Time T is A's time while at absolute rest and T" is A's time while moving at velocity v_{12}. Time T' is the time of B's clock in relation to A's. A's time is longer than B's time by the factor $1/\alpha$ because the acceleration is that of A instead of B.

Observer B moves relative to Observer A in time T the distance X at velocity v_1. In order to catch up with Observer B, Observer A accelerates from relatively at rest to velocity v_{12}. The time T" it takes A to catch up with B is according to their difference in their speed. This difference is $v_{12} - v_1$ according to A, where v_{12} is $v_2 = v_1$ relative to B. Hence

$$v = v_1 = v_2$$

$$v_{12} = \frac{v_1 + v_2}{1 + \beta_1 \beta_2} = \frac{2v}{1 + \beta^2}$$

$$T" = \frac{X}{v_{12}-v} = \frac{X}{\frac{2v}{1+\beta^2}-v} = \frac{X(1+\beta^2)}{2v-v(1+\beta^2)}$$

$$= \frac{X(1+\beta^2)}{2v-v-v\beta^2} = \frac{X(1+\beta^2)}{v-v\beta^2} = \frac{X(1+\beta^2)}{v(1-\beta^2)}$$

$$\frac{T(1+\beta^2)}{1-\beta^2} = \frac{T(1+\beta^2)}{\alpha^2}$$

The total time relative to Observer A is

$$T + T" = T + \frac{T(1+\beta^2)}{\alpha^2} = \frac{T\alpha^2}{\alpha^2} + \frac{T(1+\beta^2)}{\alpha^2}$$

$$\frac{T(1-\beta^2)}{\alpha^2} + \frac{T(1+\beta^2)}{\alpha^2} = \frac{T-T\beta^2+T+T\beta^2}{\alpha^2} = \frac{2T}{\alpha^2}$$

However, relative to Observer B, whose clock is slow by the factor $1/\alpha$, the duration of the event is shorter by the factor α. The total time of the event according to Observer B's clock is thus

$$\frac{2T}{\alpha^2}\alpha = \frac{2T}{\alpha}$$

This time is of Observer A determining Observer B moving a distance 2X' there and back as though Observer A is at absolute rest.

The Doppler Effect

The Doppler Effect, as proposed in 1842 by Christian Doppler (1803-1853), explains why a whistle on a train is of a lower pitch, as when the train is receding from the observer, and of a higher pitch, as when approaching the observer. The explanation is according to the vibration of air molecules forming waves. Lower pitch sound is stretched out weaker waves, whereas higher pitched sound is more compacted energetic waves. They stretch by either their source moving in the opposite direction in which they move or the listener moving ahead in the same direction the waves move. The exact opposite applies for shorter waves.

Doppler

The effect is also consistent with the dynamics of relative motion for ordinary particles as well as for light. The impact of bullets fired from a gun, for instance, is more energetic if the gun firing them is moving towards the target rather than away from it. It thus applies to light whether the light is either particle or wave in nature. Systems approaching each other naturally receive light signals more rapidly than do systems receding from each other.

Light, as either waves or particles called photons, thus stretch out in effect when the emitting source moves away from the observer, or the observer is moving away from the source. Furthermore, if the source producing light is in relative motion, then the light signals and their relative lengths are less frequent and less energetic because of a relatively slower clock mechanism of the source, but the principle of covariance still requires all effects to be the same for any difference in velocity between the source of light and the object receiving it.

The task is to illustrate general covariance of observers firing bullets at each other, as for comparing results with a specific Doppler effect of light propagation. Accordingly, Observer A is relatively at rest at the origin from where Observer B moves away at velocity v_1. After time T and the distance X of their separation, as according to A, A fires a bullet at B. Also, after time $T' = T/\alpha_1$ of their separation, as according to A, B fires a bullet at A. The task is to show the time for receiving a bullet is the same for A as it is for B.

First, consider the time T_b for B to receive a bullet from A is time T plus the time T_x it takes the bullet moving at velocity v_2 to catch up with B moving away from X at velocity v_1. Hence

$$T_b = T + T_x = \frac{X}{v_1} + \frac{X}{v_2 - v_1} = \frac{x(v_2 - v_1)}{v_1(v_2 - v_1)} + \frac{v_1 X}{v_1(v_2 - v_1)}$$

$$= \frac{X(v_2 - v_1) + v_1 X}{v_1(v_2 - v_1)} = \frac{v_2 X - v_1 X + v_1 X}{v_1(v_2 - v_1)} = \frac{v_2 X}{v_1(v_2 - v_1)}$$

This time is according to the clock of A. Because B's clock is slower by the factor $1/\alpha_1$, B determines the total time as

$$T_b = \frac{X\alpha_1}{v_1}\left[\frac{v_2}{v_2 - v_1}\right]$$

The task now at hand is to determine the time for A to receive a bullet from B. Since B's clock is slow by the factor $1/\alpha_1$, the time B decides to shoot a bullet at A, after B passes A, is $T' = T/\alpha_1$, at a distance $X' = x/\alpha_1$ between A and B. The speed of B's bullet is according to the addition of velocities theorem:

$$-v_{12} = \frac{v_1 + (-v_2)}{1 + \beta_1(-\beta_2)} = \frac{v_1 - v_2}{1 - \beta_1\beta_2}$$

Because A receives the bullet as moving in the negative direction, v_{12} is a negative velocity. However, the time X'/v_{12} for A to receive the bullet from

B is additional to the time X'/v_1. It is thus positive. Hence, the time that A receives the bullet is

$$T_a = T' + T'_x = \frac{X'}{v_1} + \frac{X'}{v_{12}} = \frac{X}{v_1\alpha_1} + \frac{X}{v_{12}\alpha_1} = \frac{v_{12}X}{v_1 v_{12}\alpha_1} + \frac{v_1 X}{v_1 v_{12}\alpha_1}$$

$$= \frac{v_{12}X + v_1 X}{v_1 v_{12}\alpha_1} = \frac{X(v_{12}+v_1)(1-\beta_1\beta_2)}{v_1(v_2-v_1)\alpha_1} = \frac{X}{v_1\alpha_1}\left[\frac{v_{12}(1-\beta_1\beta_2)+v_1(1-\beta_1\beta_2)}{v_2-v_1}\right]$$

$$= \frac{X}{v_1\alpha_1}\left[\frac{(v_2-v_1)+v_1(1-\beta_1\beta_2)}{v_2-v_1}\right] = \frac{X}{v_1\alpha_1}\left[\frac{v_2-v_1+v_1-v_1\beta_1\beta_2}{v_2-v_1}\right]$$

$$= \frac{X}{v_1\alpha_1}\left[\frac{v_2-v_1\beta_1\beta_2}{v_2-v_1}\right] = \frac{X}{v_1\alpha_1}\left[\frac{v_2-v_2\beta_1^2}{v_2-v_1}\right] = \frac{X}{v_1\alpha_1}\left[\frac{1-\beta_1^2}{v_2-v_1}\right]$$

$$= \frac{X\alpha_1^2}{v_1\alpha_1}\left[\frac{v_2}{v_2-v_1}\right] = \frac{X\alpha_1}{v_1}\left[\frac{v_2}{v_2-v_1}\right]$$

This time being the same as T_b, as perceived by B, is thus covariant.

A similar event for light signals is achieved by substituting c for v_2, and v for v_1, to obtain

$$\frac{X\alpha}{v}\left[\frac{c}{c-v}\right] = \frac{X\alpha}{v}\left[\frac{1}{1-\beta}\right] = \frac{X}{v}\left[\frac{\alpha}{1-\beta}\right] = \frac{X}{v}\left[\frac{\sqrt{1-\beta^2}}{1-\beta}\right]$$

$$= \frac{X}{v}\left[\frac{\sqrt{1-\beta}\sqrt{1+\beta}}{1-\beta}\right] = \frac{X}{v}\left[\frac{\sqrt{1+\beta}}{\sqrt{1-\beta}}\right] = \frac{X}{v}\left[\frac{1+\beta}{1-\beta}\right]^{\frac{1}{2}}$$

This is the time either Observer A or Observer B sees the other observer to move the distance X.

A result for A and B approaching each other is similarly obtained. The distance X of B approaching A becomes shorter, such that the time X/v is negative instead of additive. Hence

$$\frac{X'}{v} - \frac{X'}{c} = \frac{cX' - vX'}{vc} = \frac{X(1-\beta)}{v\alpha} = \frac{X}{v}\left[\frac{1-\beta}{1+\beta}\right]^{\frac{1}{2}}$$

This is the time it takes for either A or B to see the other on arrival from the distances X and X'.

The relation holds for any distance X or X', and for any time T_a or T_b. It is thus divisible into any number of distances and times. These times and distances relate to the wave properties of light, wavelength λ and frequency *f* such that

$$f' = f\left|\frac{1-\beta}{1+\beta}\right|^{\frac{1}{2}} \qquad \lambda' = \lambda\left|\frac{1+\beta}{1-\beta}\right|^{\frac{1}{2}}$$

$$f' = f\left|\frac{1+\beta}{1-\beta}\right|^{\frac{1}{2}} \qquad \lambda' = \lambda\left|\frac{1-\beta}{1+\beta}\right|^{\frac{1}{2}}$$

They represent the relativistic Doppler formulae for a light source as either approaching toward or receding from an observer at constant velocity.

Constant Speed Change

According to Newtonian Mechanics, acceleration as a change in speed increases without limit. To the contrary, the addition of velocities theorem stipulates light speed is a limit for matter to neither exceed nor even reach. However, applying the theorem to a system that constantly changes speed is complex. A change in speed from two seconds of acceleration, for instance, is simply determined in accordance with the addition of velocities theorem, but because the rate of speed change decreases as speed itself increases, the total time of acceleration entails a lot more calculation.

Speed change itself is defined constant in a manner consistent with the principle of covariance. If system P is coincident with inertial systems A, B, C, etc., as if the change from one inertial system to another occurs in equal time intervals, and as if the speed and direction of motion of B relative to A is the same as C relative to B, D relative to C, and so forth, then the change in speed is constant. If the change in speed from A to B is from v_1 to v_{12} with regard to spacetime coordinates of A, then the speed change from B to C is also from v_1 to v_{12} with regard to the spacetime coordinates of B, but with regard to the spacetime coordinates of A the speed change from B to C is from v_{12} to v_{13}. There is thus a simple progression of P changing speed from v_1 to v_{12} to v_{13} etc. The initial change in speed during coordinate time t of A calculates as

$$\frac{v_{12}t}{\sqrt{1-\frac{v_{12}^2}{c^2}}} = \frac{(2v)t}{\left[1+\frac{v^2}{c^2}\right]\sqrt{1-\frac{v_{12}^2}{c^2}}} = \frac{2vt}{\sqrt{\left[1+\frac{v^2}{c^2}\right]^2-\left[1+\frac{v^2}{c^2}\right]^2\left[\frac{(2v)}{\left[1+\frac{v^2}{c^2}\right]c}\right]^2}}$$

$$= \frac{2vt}{\sqrt{1+\frac{2v^2}{c^2}+\frac{v^4}{c^4}-\frac{4v^2}{c^2}}} = \frac{2vt}{\sqrt{1-\frac{2v^2}{c^2}+\frac{v^4}{c^4}}} = \frac{2vt}{\sqrt{\left[1-\frac{v^2}{c^2}\right]^2}} = \frac{2vt}{1-\frac{v^2}{c^2}} = \frac{2vt}{\alpha^2}$$

Since v_{13} is v_{12} with regard to B's spacetime coordinates, and since B's clock is slower by the relativistic factor α, the change from v_1 to v_{13} is in ratio to α^3 according to A's clock. Consequently there is an exponential progression of the relativistic factor by a power of 1 for each consecutive speed change with regard to the spacetime coordinates of A.

The addition of velocities theorem with regard to this relativistic speed change is applicable with regard to a relativistic modification of Newtonian Mechanics in determining the distance that occurs from the constant speed change. A distance d of acceleration relative to A is vt, as the time taking P to catch up with B moving at speed v away from A. The distance in relation to the acceleration of P is derived in the manner

$$d = vt = \frac{2vt}{1+\frac{v^2}{c^2}+1-\frac{v^2}{c^2}} = \frac{2vt}{1+\frac{v^2}{c^2}+\sqrt{\left[1-\frac{v^2}{c^2}\right]^2}} = \frac{2vt}{1+\frac{v^2}{c^2}+\sqrt{1-\frac{2v^2}{c^2}+\frac{v^4}{c^4}}}$$

$$= \frac{2vt}{1+\frac{v^2}{c^2}+\sqrt{1+\frac{2v^2}{c^2}+\frac{v^4}{c^4}-\frac{4v^2}{c^2}}} = \frac{2vt}{\left[1+\frac{v^2}{c^2}\right]+\sqrt{\left[1+\frac{v^2}{c^2}\right]^2-\frac{4v^2}{c^2}}}$$

$$= \frac{2vt}{\left[1+\frac{v^2}{c^2}\right]+\left[1+\frac{v^2}{c^2}\right]\sqrt{1-\frac{(2v)^2}{c^2\left[1+\frac{v^2}{c^2}\right]^2}}} = \frac{v_{12}t}{1+\sqrt{1-\frac{v_{12}^2}{c^2}}}$$

Significantly, if v_{12} is extremely small in comparison to light speed, as for a negligible effect of the relativistic factor such that it approximates as 1, then the above result compares with a Newtonian non-relativistic one as

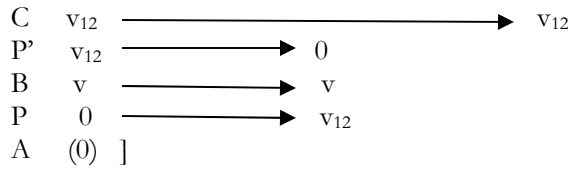
$$d = vt \approx \frac{1}{2}at^2$$

By Newtonian Mechanics, v is the average speed of P from 0 to 2v, but by the addition of velocities theorem the change in speed is from v = 0 to v_{12} whereby the average speed v is slightly less than v_{12} because of the decrease in the rate of speed change at relatively higher speeds. The difference in the results is negligible except for greater changes in speed from 0 to nearly that of light.

The speed v thus has a different interpretation with regard to the result of the SRT interpretation differing from that of Newtonian Mechanics. The difference is explained according to an asymmetrical analysis of covariance.

Covariance is essentially conditional to symmetry, but the explanation of the clock paradox is according to an asymmetrical condition. Conditions

of asymmetry are pertinent to constant speed change as well. Consider, for instance, the following illustration.



Covariance here applies with regard to the symmetry of A, B C, P and P' simultaneously meeting wherefrom B relatively moves at velocity v away from A and at velocity –v away from C. Symmetry also occurs with regard to the momentary speeds of P and P' being v relative to B at the moment they catch up with B. However, there is asymmetry between B and A, and between B and C. B perceives a different change of speed of either P or P' as 2v, as from either –v to v or from v to –v, which is a greater change than from 0 to v_{12}, as by means of the slower clock of B determining a shorter duration for a quicker acceleration. Still, v is the speed of B relative to A in determining d as the distance separating B, P and P' from A at time t. Since the speed of B is v relative to either A or C, and the speed of either A or C is v relative to B, and because the initial and final speeds of P and P' are v as well relative to B, P and P' initially move in opposite direction away from B relative to B at speed v to slow to relatively at rest with B and return to B in opposite direction in regaining speed v, as required by covariance.

MASS-ENERTY DYNAMICS

Similar to the clock paradox is one with regard to relative mass. It is with regard to how masses in relative motion collide, stick together and maintain the same relative mass while in relative motion. To the contrary, the mass in relative motion is relatively greater than if it is relatively at rest, yet the total mass is also conserved by inelastic collision.

The condition of a relative increase in mass and no relative increase in mass is consistent in agreeing with observation and the formulation of SRT. An increase in relative mass with an increase in motion is also derivable in a manner consistent with the conservation laws of momentum and mass. The derivation is initially with regard to an inelastic collision between two equal rest masses whereby a resolution of the paradox is explained with regard to how energy of relative motion is maintained either internally as the result of inelastic collision or used to reverse inelastic collision as elastic collision.

As the paradox is with regard to how masses in relative motion collide, stick together and maintain to have the same relative mass while relatively at rest, the resolution of the paradox considers elastic collision as an inelastic one plus its reverse process. Even though the reverse process is opposite to inelastic collision, it differs inasmuch as an exchange of mass occurs from elastic collision. The two conditions are asymmetrical, but the resolution of the clock paradox was also according to the asymmetry of acceleration, and collisions between masses are a means of acceleration as either symmetrical or asymmetrical effects. Asymmetry of elastic and inelastic collision results from the inelastic collision having other options to how a conditional state of equilibrium is restored. It is asymmetrical when kinetic energy of inelastic collision converts to another form instead of the relative motion before the collision by means of elastic collision.

The resolution of the relative mass paradox applies more generally to other phenomena. Relative mass and momentum are conserved with regard to reflection, absorption and emission of light by matter whereby Einstein's

mass-energy equation $E = mc^2$ is derived. In addition, a classical concept of kinetic energy is redefined as the difference between rest mass and mass in relative motion. Moreover, the dynamics of gravity are shown as consistent with the dynamics of relative motion according to an equivalence of inertial and gravitational mass.

There is also another condition of relativity to consider with regard to a change in total mass in view of an observer's changed state resulting from collision. All other mass apart from collision relatively changes with regard to a change in speed of the observer.

As to why mass-energy conservation does not necessarily result from a change in speed of the observer, it is a more complex issue including effects of gravity and the probability condition of quantum physics. A possibility of complete mass-energy conservation is explained later on as conditional to a unification of general relativity and quantum electrodynamics with regard to our universe only being an observable part of a multiverse.

Relative Mass

According to special relativity a 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:

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

Mass-energy according to theory is conserved after collision. If the collision is inelastic, wherefrom relative motion between masses is terminated, then total mass-energy remains unchanged, providing, that is, it is observed from the same reference frame of motion.

Despite this apparent contradiction, an increase in relative mass along with an increase in relative motion is verifiable mathematically according to the conservation principles of mass-energy and momentum. Constant light speed and covariance also apply, as does the addition of velocities theorem.

Relative mass is first distinguished from the rest mass. Let m_0 be the mass relatively at rest with either Observer A or Observer B. Let m be the same quantity mass if moving with Observer B at velocity v_1 relative to the positive direction towards Observer A. Mass m and mass m_0 become one, say M, relative to Observer A by way of inelastic collision. Conservation of mass and conservation of total momentum apply according to equations (2) and (3):

$$m + m_o = M \tag{2}$$

$$mv_1 + m_o(0) = mv_1 = Mv_2 \tag{3}$$

Equation (2) illustrates the total mass is the same before and after inelastic collision. Equation (3) is somewhat more complex in that $m_o(0)$ is at rest with Observer A before collision. Total momentum relative to Observer A before the collision is thus only mv_1. Because both masses move at velocity v_2 after inelastic collision, the total momentum relative to Observer A is also Mv_2.

By substituting m and m_0 of equation (2) for M in equation (3), the latter becomes

$$mv_1 = (m + m_0)v_2$$

$$mv_1 = mv_2 + m_0v_2$$

$$mv_1 - mv_2 = m_0v_2$$

$$m(v_1 - v_2) = m_0v_2$$

$$m = \frac{m_0v_2}{v_1 - v_2} \tag{4}$$

The objective is to verify

$$m = \frac{m_0v_2}{v_1 - v_2} = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{5}$$

$$\frac{m}{m_0} = \frac{v_2}{v_1 - v_2} = \frac{1}{\sqrt{1 - \frac{v_1^2}{c^2}}} \tag{6}$$

$$\frac{v_2}{v_1 - v_2} = \frac{1}{\sqrt{1 - \frac{v_1^2}{c^2}}} \tag{7}$$

$$\sqrt{1 - \frac{v_1^2}{c^2}} = \frac{v_1 - v_2}{v_2} = \frac{v_1}{v_2} - 1 \tag{8}$$

$$v_2\sqrt{1 - \frac{v_1^2}{c^2}} = v_1 - v_2 \tag{9}$$

$$v_2^2\left[1 - \frac{v_1^2}{c^2}\right] = v_1^2 - 2v_1v_2 + v_2^2 \tag{10}$$

$$v_2^2 - \frac{v_1^2 v_2^2}{c^2} = v_1^2 - 2v_1 v_2 + v_2^2 \tag{11}$$

$$-\frac{v_1^2 v_2^2}{c^2} = v_1^2 - 2v_1 v_2 \tag{12}$$

$$2v_1 v_2 = v_1^2 + \frac{v_1^2 v_2^2}{c^2} = v_1^2 \left[1 + \frac{v_2^2}{c^2}\right] \tag{13}$$

$$2v_2 = v_1 \left[1 + \frac{v_2^2}{c^2}\right] \tag{14}$$

$$v_1 = \frac{2v_2}{1 + \frac{v_2^2}{c^2}} \tag{15}$$

Equation (15) is of the form of the addition of velocities theorem.

Equation (15) relates to equation (1) in a manner of the elastic collision being a reversal of inelastic collision. Consider v_1 is the initial velocity of m towards $m_o(0)$; v_2 is the velocity of m_x after inelastic collision. In relation to the addition of velocities theorem, v_1 further pertains to the result of elastic collision as the reversal of inelastic collision with regard to the changes in velocities of m_o and m_x. By covariance, velocities v_2 of $m_o(0)$ relative to m_x and $-v_2$ of m_x relative to $m_o(0)$ are the same speed. This covariant symmetry further applies to the reversal of inelastic collision. The change in speed of $m_o(0)$ from v_2 to 0 with regard to m_x being relatively at rest is from 0 to v_2 from the reversing of inelastic collision. However, with respect to $m_o(0)$ as relatively at rest, it is according to the addition of velocities theorem for the twice change of v_2 from 0 and from v_2.

The conservation of mass in inelastic collision indicates a paradox with regard to the same mass being relatively greater if in relative motion, but the paradox is resolved with regard to conservation of mass only applying as a momentary state of collision. If the collision is inelastic, mass is conserved by internal motion of the system, as heat or some other form of energy. If the collision is elastic, relative motion and mass are maintained by means of exchanging mass and relative motion.

Mass-Energy and Light

Say inelastic collision occurs between two masses for them to become internally the same as they were in relative motion. The law of conservation of energy maintains. For, if collision is inelastic in nature, then motion stops unless it continues as some other form of energy. Internal energy could be stored, for instance, as heat or molecular motion. With elastic collision, the

kinetic energy is restored as relative motion of the masses. For a collision to remain inelastic whereby the same mass content of a system remains as it was before collision, the internal energy of motion caused by the collision is spent to maintain in a state of equilibrium with its environment. It could be spent either as the internal motion of molecules of matter or as radiant heat, as for different way to restore thermodynamic equilibrium.

Heat is viewed as the random motion of internal molecules of mass, but conservation of relative mass and momentum also applies to molecular motion. The molecules are not able to directly surrender their motion to molecules when they are separated by empty space. However, there is still a possibility to consider of heat being absorbed and emitted as radiant energy, such as is light.

Since energy is conserved of masses in collision by them exchanging it, a kinetic energy of relative motion also maintains in some form or another. Einstein agreed. Mass and energy according to SRT are equivalent whereby the mass content of a body is only one of many possible forms of energy as convertible from one form to another.

Consider a form of energy as that of light. Light emitted, absorbed or reflected by matter constitutes pressure, as according to an electromagnetic theory that was derived by Maxwell in the middle of the 19th century, and as was verified by experiment in the year 1890 by Peter Lebedew (1866-1911). Reflection and absorption of light by two lightweight flags, for instance, can cause them to rotate around a tiny pole if attached opposite to each other, as by one side of each flag being white to reflect light and the other side of each flag being black to absorb it. The absorption of light by one flag while the other flag reflects it results in unequal momenta.

Einstein equated the internal energy of mass as a product of mass and light speed squared in the manner

$$E = \frac{E_0}{\sqrt{1-\frac{v^2}{c^2}}} = mc^2 = \frac{m_0c^2}{\sqrt{1-\frac{v^2}{c^2}}}$$

The mass m_0 is the rest mass of m moving at velocity v, and m_0c^2 is the "internal energy constitutive of the rest mass". The rest mass in relative motion increased by $m - m_0$ is identified as the kinetic energy potential for relative motion in approximation of the kinetic energy equation for speeds far below that of light: $K = (½)m_0v^2$.

Einstein explained the relation according to a tube with two spheres of mass positioned at each end of the tube. The two spheres are here denoted as A and B. Total mass M is of the tube and spheres considered relatively at rest, except for sphere A having an excess amount of potential energy E_0. A photon of light with energy E_0 is emitted from sphere A to sphere B at

speed c and momentum E_0/c. The tube of spheres recoils in the opposite direction that speed v and momentum Mv do. Conservation of momentum applies such that

$$Mv = \frac{E_0}{c} \tag{1}$$

$$v = \frac{E_0}{Mc} \tag{2}$$

Equation (2) is to be used to substitute values.

Momentum is negated when sphere B absorbs the light and passes it on to the tube by means of inelastic collision with momentum of the same magnitude moving in an opposite direction, but displacement occurs from one sphere to the other during time t of light propagation as

$$x = vt \tag{3}$$

Substituting E_0/Mc of equation (2) for v of (3) gives

$$x = \frac{E_0 t}{Mc} \tag{4}$$

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 a distance d back to sphere A. With all the other related activity balancing out on the transporter's return trip, the transportation causes the tube to move back a distance x to its original position.

Work occurring for the tube to move the distance x equals the product dm_0 in regard to the mass m_0 is a measure of weight. Since the particle and the light are of the same energy, and since the work energy was used by the particle in replacing the light energy back to its original position, which is a process restoring the original position of the tube, the actions equate in the manner

$$xM = dm_0 \tag{5.1}$$

$$x = \frac{dm_0}{M} \tag{5.2}$$

Combining equations (4) and (5.2) gives

$$x = \frac{dm_0}{M} = \frac{E_0 t}{Mc} \tag{6}$$

The last two equalities give

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

$$E_0 = \frac{Mm_0 cd}{Mt} = \frac{m_0 cd}{t} \tag{7}$$

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

$$E_0 = m_0 c^2 \tag{8}$$

The last equation is the internal energy constitutive of the rest mass m_0.

Since the mass in relative motion is increased by a factor $(1 - v^2/c^2)^{-1/2}$, the mass-energy equation is

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

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

Conserving Light Energy

Since light possesses momentum, its emission and absorption by mass is subject to the conservation laws of momentum and energy. Verification is with regard to mass $m_0 = 1$ with momentum $m_0(0) = 0$ relative to Observer A absorbing a photon of light having momentum $m_x c$ such that m_0 and the photon energy move with Observer B at velocity .6c relative to Observer A. Conservation of momentum with regard to the total mass of both light and matter with respect to A is 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 with respect to A before and after absorption is thus

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

Total momentum before collision was (3/2)(1) = 3/2 light speed units. It is also (3/2 + 1)(3/5) = (5/2)(3/5) = 3/2 light speed units after collision. The total momentum is thus conserved with regard to absorption and emission of light by matter.

Note: Since the total mass before and after the collision is simply m_x + m_0 = 2.5 units with respect to A, it is also conserved, as in accordance with inelastic collision.

For a reverse process of inelastic collision as elastic collision, a photon is emitted from total mass m_x + m_o in an opposite direction at which it was absorbed, and with energy relative to B, who perceives the change in mass and momentum of emission the same as its absorption. According to A, the velocity of m_0 after emitting the photon becomes

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

The relative mass becomes

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

Its momentum becomes

$$\frac{17}{8}m_0 \cdot \frac{15}{17}c = \frac{15}{8}m_0 c$$

The photon mass in the opposite direction is

$$m_{xb} = m_x \left|\frac{1-v_{12}}{1+v_{12}}\right|^{\frac{1}{2}} = \frac{3}{2}m_0 \left|\frac{c-\frac{15}{17}c}{c+\frac{15}{17}c}\right|^{\frac{1}{2}} = \frac{3}{8}m_0$$

Total mass and total momentum with respect to A are again

$$\frac{17}{8}m_0 + \frac{3}{8}m_0 = \frac{5}{2}m_0$$

$$\frac{17}{8}m_o\,\frac{15}{17}c - \frac{3}{8}m_0 c = \frac{3}{2}m_0 c$$

Both mass and momentum of light and matter are thus conserved of elastic collision between light and matter by means of a transfer of mass between light and matter.

Since the total energy of matter relatively at rest equals the product of mass and light speed squared, and since elastic collision between matter and light involves a transfer of mass for its conservation, implications are matter is essentially a collection of light energy. However, no direct conversion of rest mass to relativistic mass occurs by absorbing light by inelastic collision:

$$\left(m_x = \frac{3m_0}{2}\right) + m_0 = \frac{5m_0}{2} \neq \frac{m_0}{\sqrt{1-(.6c)^2}} = \frac{5m_0}{2}$$

Internally, the absorption of light increases internal energy of matter (as the atomic molecules) for a gain in weight from matter absorbing light.

According to this mathematical analysis momentum and mass-energy are conserved with regard to the interaction of light and matter by means of an exchange of mass. However, this analysis does not conclude that light is itself mass. To the contrary, light does not contain mass neither according to either relativity theory or Quantum Mechanics (QM). For mass to move at light speed it is increased to infinite mass according to relativity theory. According to QM, different light is able to occupy the same space whereas matter cannot. Light and matter are thus merely different forms of energy converting from the one to the other, and conservation of mass is only with regard to light conserving it potential existence.

Explaining Gravity

By theory, any particle moving at light speed is massless. A conversion of light energy to mass-energy is by the direct interaction of light and mass according to relativity theory; according to QM, there are massless particles moving at light speed, such as the Higgs particle, acquiring mass in slowing through a Higgs field, as a virtual field of potential energy. This mechanism is also in compliance with conservation of energy in that it is neither created nor destroyed but only converted from one form to another, as slower light converted into kinetic energy of relative motion.

The Higgs mechanism succeeded as part of the unification of three of four fundamental forces of nature: the strong nuclear force, the weak force of subatomic particle decay and electromagnetism. Why the weak force has a much shorter range than the electromagnetic force, for instance, is due to otherwise massless particles acquiring mass from moving through the Higgs field. However, although the Higgs mechanism explains particular creations of mass on the atomic scale, it does not explain a general creation of mass,

and the gravitational force still has not successfully been included as part of this unification.

A similar field to the Higgs field is a gravitational field in its slowing of massless particles from light speed. The gravitational field is more general in applying to all mass of the field according to the principle of equivalence. In a weak field of weak force, only W and Z bosons (massless particles) move slower in converting into mass. Electromagnetic radiation is not slowed by the weak field, whereas the gravitational field slows the motion of all matter and all electromagnetic waves, such as visible light or otherwise.

According to the principle of equivalence the forces of relative motion apply to gravity as well. To explain gravity as such, consider it as a particular field created by the presence of mass. The Higgs particle is very massive but extremely short lived in creating a vacuum effect for a boundary condition. Consider a more general vacuum effect for matter as its gravitational field. Matter converts to gravitational radiation in creating a vacuum effect in the wake of the emitted radiation. If the amount of gravitational radiation is in direct proportion to the amount of mass, and if two emissions occur from the same place and are emitted in exact opposite directions according to the Doppler principle, then the dynamics of the field maintain consistent with the dynamics of relative motion according to an equivalence of inertial and gravitational mass.

What is still required of this explanation of gravity is to explain further how it complies with conservation of energy. How, for instance, does mass continue to create gravitational radiation without using up the energy of the field? The action must be similar to an inelastic collision whereby energy is internally converted into another form. The gravitational radiation need also convert into another form for a recycling process. It thus has a range for it to convert from a massless particle to an inertial condition of a gravitational field and then into mass. The conversion constitutes an adiabatic process as an equilibrium state in replacing the matter emitted as gravitational radiation by converting the energy of the gravitational field by means of the vacuum effects created from the departure of gravitational radiation.

In the last chapter of this book it is shown that the Hubble Constant mathematically complies with this explanation.

GENERAL RELATIVITY ANALOGIES

After modifying Newtonian Mechanics to comply with relative spacetime instead of absolute space and absolute time, Einstein focused on Newton's theory of gravity for it to comply with the conditions of special relativity. A reasonable connection is that gravity is analogous to relative motion by way of the equivalence between gravitational and inertial mass. He postulated it as the founding principle to formulate the more general theory of relativity whereby inertial mass and gravitational mass are one and the same thing.

Another principle he used in relating it is similar to one Copernicus previously invoked to explain our unawareness of Earth's orbital motion. Copernicus realized that we are unaware of Earth's motion around the sun because we are in uniform motion with Earth's. Similarly, Einstein realized we are internally unaware of falling freely by gravity because, as determined by Galileo, all mass falls at the same rate through a vacuum towards Earth's center.

Einstein thus equated free fall with inertial motion insofar as there is no internal awareness of either one. However, the free fall of Earth with its moon is felt by way of ocean tides, as caused by a stronger pull of the part of Earth closer to the moon. Since light also gravitates toward matter, and since the constancy of light speed is the founding principle of SRT, Einstein relegated its validity as a special case, as applicable insofar as tidal effects are negligible. He then opted for a geometrical description of gravity according to spacetime curvature due to the presence of mass.

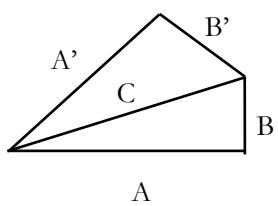
There are other anomalous effects to consider for distinguishing free fall from inertial motion. There is, for instance, a mass tendency to gravitate towards a common center instead of in parallel directions. Spacetime is thus curved due to the presence of mass wherefrom special relativity is valid only insofar as internal effects of gravity are negligible. However, this restriction of SRT does not mean it is not an integral part of describing the properties of nature. Gravity, as according to the equivalence of gravitational mass and

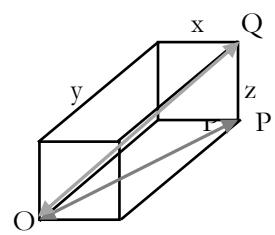
inertial mass, is still a form of energy that should be in compliance with the laws of gravity the same as for motion. Tidal effects occur because gravity is a form of acceleration and is an inhomogeneous condition of spacetime. A condition of free fall analogous to inertial motion is only valid inasmuch as the inhomogeneous nature of gravity is negligible in effect.

Even though Einstein opted to stipulate SRT is valid only as a special case, it is here considered an integral part of GRT inasmuch as the latter is analogous to the former. Analogies of relativistic effects of SRT and GRT are with regard to retardation of clocks, contraction of space and so forth. They relate in accordance with a mathematical invariance of SRT in further accordance with the Schwarzschild Metric, which is a solution of Einstein's general field equations proposed by Karl Schwarzschild (1873-1916).

Invariance

The Pythagorean Theorem is useful in surveying when the line of sight of a direct measure is blocked by an obstacle in the way. The right triangle maps an alternative direction as a detour, with the hypotenuse as the actual distance to be measured according to the two other legs of the triangle as the detour. Because the two other legs can extend in any two perpendicular directions from the ends of the hypotenuse, their relation to the hypotenuse determines an invariant for all right triangles formed from it. In the case of the illustration below on the left the invariant is of the form $C^2 = A^2 + B^2 = A'^2 + B'^2$. A^2 and A'^2 differ from B^2 and B'^2, but the total area of C^2 is the same.





$$\overline{OP}^2 = x^2 + y^2$$
$$s^2 = \overline{OQ}^2 = \overline{OP}^2 + z^2 = x^2 + y^2 + z^2$$

This invariance also applies to higher dimensions, as illustrated by the rectangular box above on the right. Length OP is the hypotenuse of a right triangle with its other sides as x and y. Length OQ is also a hypotenuse of a right triangle with its other sides as OP and z. Length OQ is thus according to the legs of two right triangles of sides x,y,z.

Physics includes among other things time and motion, and with SRT as first formulated by Einstein and then given geometrical interpretation by

Hermann Minkowski (1864-1909), time becomes a fourth dimension of the spacetime interval

$$s^2 = x^2 + y^2 + z^2 - c^2t^2 = x'^2 + y'^2 + z'^2 - c^2t'^2$$

The letter s denotes the interval, as to determine a value of a variable of one coordinate system if other values of two coordinate systems are known.

Invariance of the interval derives from the Lorentz transformations:

$$x' = \frac{x-vt}{\sqrt{1-\beta^2}} \quad , \quad y' = y \quad , \quad z' = z \quad , \quad t' = \frac{t-\frac{vx}{c^2}}{\sqrt{1-\beta^2}}$$

For the derivation, time coordinates are converted into distance coordinates in the manner

$$ct' = \frac{ct-\beta x}{\sqrt{1-\beta^2}}$$

The coordinates are then added and subtracted in the manner

$$ct' + x' = \frac{ct-\beta x}{\sqrt{1-\beta^2}} + \frac{x-vt}{\sqrt{1-\beta^2}} = \frac{ct-vt+x-\beta x}{\sqrt{1-\beta^2}} = \frac{ct(1-\beta)+x(1-\beta)}{\sqrt{1-\beta^2}}$$

$$ct' - x' = \frac{ct-\beta x}{\sqrt{1-\beta^2}} - \frac{x-vt}{\sqrt{1-\beta^2}} = \frac{ct+vt-x-\beta x}{\sqrt{1-\beta^2}} = \frac{ct(1+\beta)-x(1+\beta)}{\sqrt{1-\beta^2}}$$

The product (t' + x')(t' – x') gives

$$t'^2 - x'^2 = \left[\frac{ct(1-\beta)+x(1-\beta)}{\sqrt{1-\beta^2}}\right] \cdot \left[\frac{ct(1+\beta)-x(1+\beta)}{\sqrt{1-\beta^2}}\right]$$

$$= \frac{c^2t^2(1-\beta^2)-ctx(1-\beta^2)+cxt(1-\beta^2)-x^2(1-\beta^2)}{1-\beta^2} = c^2t^2 - x^2$$

Hence, invariance of the interval is of the form

$$s^2 = c^2t'^2 - x'^2 = c^2t^2 - x^2$$

$$\frac{s^2}{c^2} = t'^2 - \frac{x'^2}{c^2} = t^2 - \frac{x^2}{c^2}$$

$$\frac{s^2}{t^2} = c^2 - \frac{x^2}{t^2} = c^2 - v^2$$

$$\frac{s^2}{t\prime^2} = c^2 - \frac{x\prime^2}{t\prime^2} = c^2 - v^2$$

Significantly, invariance of the interval is simpler and more convenient for relating different phenomena. In the same manner of relating spacetime coordinates, for instance, momentum and energy are

$$\frac{s^2}{c^2} = P_x^2 + P_y^2 + P_z^2 - \frac{E^2}{c^2} = P_{x'}^2 + P_{y'}^2 + P_{z'}^2 - \frac{E'^2}{c^2}$$

$$s^2 = P_x^2 c^2 + P_y^2 c^2 + P_z^2 c^2 - E^2 = P_{x'}^2 c^2 + P_{y'}^2 c^2 + P_{z'}^2 c^2 - E'^2$$

The total energy of a system thus calculates by simply knowing variables of energies or momenta of one system in comparison to another.

The Schwartzschild Metric

The Schwarzschild metric is a solution of the field equations of GRT interpreting the inverse square law for gravity of Newtonian Mechanics in view of space-time curvature. Although its validity now applies to only the empty space of the gravitational field outside the radius of the gravitating mass, an analogous interpretation of gravity and relative motion reduces the mathematical form of the Schwartzschild Metric to that of SRT.

The Schwarzschild metric is of the form

$$ds^2 = \left[1 - \frac{2GM}{rc^2}\right] c^2 dt^2 - \left[1 - \frac{2GM}{rc^2}\right]^{-1} dr^2 - r^2 d\theta^2 - (sin^2\theta) d\varphi^2$$

In physics, the metric relates coordinate lengths as infinitesimal increments ds, as for allowing for a calculation of them in terms of an invariant. Time and distance increments in the Schwarzschild metric pertain to a relatively homogeneous gravitational field within a volume of infinitesimal space, as where ds is an increment of the invariance. For instance, Earth's gravity at a foot higher from the ground is only slightly decreased in comparison to its decrease many miles up. At only an inch higher up it is even more the same. For an infinitesimal increase in height it converges to a homogeneous state, which is comparable to Newtonian Mechanics as well.

Increments dr and dt represent distance and time, respectively, and the last two terms of the metric with trigonometric quantities θ and φ refer to polar coordinates in place of the standard coordinates y and z in view of flat spacetime. Flat spacetime calculates as conditional to the gravitationally free space of SRT whereby the Newtonian gravitational escape velocity squared of mass M is 2GM/r = 0.

As the letter c represents light speed in a vacuum of gravitational free space, a relativistic modification of it according to the Schwarzschild metric is in order. As for explaining this modification in its right context, a square roots of either $(1 - v^2/c^2)$ or $(1 - 2GM/rc^2)$ is referred to as the relativistic factor α. Relative means comparable to, and relativistic means a comparable effect of either relative motion or a gravitational field. In the Schwarzschild metric, it distinguishes effects of mass-energy, distance, time and so forth in a gravitational field apart from gravitational free space.

The Upper Limit

A particular interpretation of the Schwartzschild Metric is the result of black holes and their singularities. At $r = 2GM/c^2$ the Schwarzschild radius is representative of an upper limit for c as an escape velocity of the field. It is referred to as an event horizon for the possible existence of a black hole. It is further assumed the gravitational mass density of the field collapses to a point of no size as a singularity with regard to the relativistic factor in the Schwartzschild Metric equaling zero at its upper limit. As by ignoring polar coordinates, the metric is of the form

$$ds^2 = c^2dt^2\left[1 - \frac{2GM}{rc^2}\right] - dr^2\left[1 - \frac{2GM}{rc^2}\right]^{-1}$$

$$\frac{ds^2}{dt^2} = c^2\left[1 - \frac{2GM}{rc^2}\right] - v^2\left[1 - \frac{2GM}{rc^2}\right]^{-1}$$

If $dr/dt = v = 0$, then the metric becomes

$$\frac{ds^2}{dt^2} = c^2[1 - 0] - 0 = c$$

It is that of light speed in gravitational free space. If $2GM/r = c^2$, as an escape velocity squared, then the equation becomes

$$\frac{ds^2}{dt^2} = c^2\left[1 - \frac{c^2}{c^2}\right] - \frac{c^2}{1 - \frac{c^2}{c^2}} = 0 - \infty$$

A result of zero minus infinity is a mathematical singularity. Consequently, if c is an upper limit whereby nothing can escape, a possible interpretation is that the spacetime radius c(dt) shrinks to zero for an infinite mass density with regard to a singularity within an event horizon known as a black hole.

The black hole had previously been considered in view of Newtonian Mechanics. John Michell had speculated in 1783 that light is subject to the

force of gravity. Pierre-Simon Laplace speculated in 1796 that it is possible for a gravitational escaped velocity greater than light speed to prevent light from escaping.

The original interpretation of the black hole was that nothing including light is able to escape its presence. It therefore appears black. However, the black hole was redefined by Stephen Hawking for it to be able to evaporate by emitting Hawking radiation. Jacob Bekenstein had applied the 2nd law of thermodynamics, as in a journal published in 1972, indicating the necessity of radiation for conservation of entropy and energy. Hawking subsequently, as in a 1975 journal, applied probability conditions of quantum physics such that there is a probability a particle inside the black hole exists outside it as well. Black holes are thus allowed to evaporate, which also seems necessary for compliance with big bang cosmology in allowing the universe to expand from the singularity as a dimensionless point inside a black hole.

Variable Light Speed

A particular distinction that is indicative of a modification of SRT, as according to the Schwarzschild metric, is that of a slower light speed in a gravitational field. According to the principle of simultaneity of SRT, events are coordinated, as seen, according to constant light speed. If the particular event is a particle of light, then the difference in speed of the particle and its observation is zero. Hence, the interval becomes ds = 0 for obtaining

$$0 = c^2dt^2\left[1-\frac{2GM}{rc^2}\right] - dr^2\left[1-\frac{2GM}{rc^2}\right]^{-1}$$

$$dr^2\left[1-\frac{2GM}{rc^2}\right]^{-1} = c^2dt^2\left[1-\frac{2GM}{rc^2}\right]$$

$$\frac{dr^2}{dt^2} = c^2\left[1-\frac{2GM}{rc^2}\right]^2$$

$$\frac{dr}{dt} = c\left[1-\frac{2GM}{rc^2}\right] = c'$$

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

Significantly, in the absence of a gravitational field, 2GM = 0, whereby the relativistic factor squared reduces to the number one for no change in light speed. Even in a gravitational field, local observers on Earth's surface perceive local light speed relatively the same as if in gravitational free space. It is thus possible to describe light speed as constant in a gravitational field, as to how a non local observer in gravitational free space interprets how a local observer in a gravitational field perceives light speed also as constant.

Consider the moon's orbit about Earth as a natural clock. The clock is relatively slower within the gravitational field of the sun because its orbital motion around Earth is slower according to the Schwartzschild Metric. For earthlings, however, the slowing of a clock by the sun's gravitational field is nullified by the proportional slowing of matter and light by the same factor.

Consider the same event as perceived by an observer outside the sun's gravitational field. Instead of interpreting light speed and relative motion in the field as slow, spacetime of the field is interpreted as relatively expanded instead. The moon's orbital distance from Earth is thus greater, and in view of the Newtonian potential $Gm/r = v^2$ the total mass of the field is greater as well.

How does mass entering into a gravitational field result in an increase in total mass-energy and not violate the law of conservation of energy?

An increase in mass-energy is contrary to the laws of thermodynamics in that work energy between systems is spent instead of gained, and that the gravity between masses constitutes work energy for change. This condition was noted by Bekenstein from which Hawking decided to modify the black hole to comply with probability conditions of Quantum Electrodynamics.

If the black hole is redefined to allow it to emit Hawking radiation, the singularity might also be redefined as well in order for it to allow expansion of the universe. A mathematical possibility, for instance, is to reinterpret the relativistic factor of the metric as well.

SRT and GRT Analogies

For mathematical consistency of this interpretation consider again the form of the Schwarzschild Metric as

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

Again, instead of interpreting light speed in the gravitational field as slower, spacetime is arbitrarily interpreted as relatively expanded. Replacing c with c' obtains

$$ds^2 = c^2dt^2\left[1 - \frac{2GM}{rc^2}\right] - \frac{dr^2}{1-\frac{2GM}{rc^2}} = \frac{c'^2dr^2}{1-\frac{2GM'}{r'c'^2}} - \frac{dr^2}{1-\frac{2GM'}{r'c'^2}}$$

The meaning of this equation is simply with regard to the outside observer interpreting how the observer in the field determines the nullification effect of slower light speed due to a relatively greater spacetime.

Consider M' and r' are relativistic comparisons with respect to M and r inasmuch as c'^2/c^2 nullifies $M'r/Mr'$:

$$\frac{2GM'}{r'} = \frac{2G(M\alpha^2)}{(r\alpha^{-2})} = c'^2 = c^2\alpha^4$$

This form of the metric indicates that the mass M of the gravitational field decreases to M' by the square of the relativistic factor and r increases to r' by the square of the relativistic factor. Moreover, since all relative motions in the gravitational field, as including light speed c and escape velocity v, are slowed by the same relativistic factor squared, and because $2GM/R = v^2$ is an escape velocity squared, it follows that $v'^2/v^2 = c'^2/c^2$ maintains if $r/r' = M'/M = c'/c = v'/v$. The radius r is thus increased by the relativistic factor squared whereas the total mass M of the field is decreased by it.

Note: The distance dr in this form of the metric is not changed. As for an interpretation, it is with regard to a relative increase in gravitational mass of the field in analogy to how a relativistic increase in mass results because of its relative motion. Because the outside observer interprets spacetime of the field as relatively increased, as instead of orbital speeds in the field being relatively slower, and because an orbital speed is determined according to a ratio of the orbiting distance from a mass, the relative mass also increases in order to maintain with a relative increase in radius. Consequently, observers outside the field still determine the mass of the field as relatively increased.

Further interpretation of the Schwartzschild Metric is that an observer outside the field interprets mass-energy inside the field as relatively greater, and observers inside the field conversely interpret mass-energy outside the field as relatively less. However, if a relativistic radial contraction occurs in analogy to the contraction of length in the direction of relative motion, then the relative increase in spacetime is nullified. A relatively slower time within the field also nullifies a slower clock's timing of shorter distances, such that time and mass become universal constants. The Schwartzschild Metric is, in effect, nullified. However, this nullification is neither consistent with theory nor empirical observation.

Einstein considered analogical effects of gravity with relative motion as early 1906 with regard to the principle of equivalence. He concluded in 1911 that the light spectrum is blue shifted by entering into a gravitational field and redshifted by leaving it. The analogy is with regard to a constant speed change whereby the spectrum of light catching up with the observer is redshifted whereas it is blue-shifted if it is approaching from the opposite direction of motion. Likewise, as according to the principle of equivalence a gravitational acceleration of light also causes the light spectrum to be blue-shifted whereas the spectrum of light escaping from gravity is redshifted.

The shifts in light spectrum naturally occur as such if clocks within the field are relatively slow. Although light speed is also relatively slower in the field, its frequency remains the same, as by having a contracted wavelength

in compensating for its slower speed. Light created outside the field is thus relatively more energetic within the field, whereas light created in the field is relatively less energetic outside the field.

In being consistent with the Schwartzschild Metric note that the speed of light and relative motion decrease by the square of the relativistic factor, as does c(dt) squared, whereas dr squared increases by the relativistic factor squared. Distances and times of events in the field are thus in proportion to the relativistic factor instead of it squared. Because the radial contraction of mass in the field only occurs according to the relativistic factor instead of it squared, because the moon's orbit around a planet is a natural clock, and because its orbital speed is slow by the relativistic factor squared, its orbital distance is only shorter by the relativistic factor as the natural clock that is only slow by the relativistic factor. In effect, it is consistent with length c(dt) only decreased in proportion to only the relativistic factor.

The radius c(dt) decreasing by the relativistic factor corresponds with a relativistic decrease in mass density. It is in compliance with conservation of energy with regard to gravity being constitutive of work energy that is spent in maintaining a form of acceleration. However, at a particular mass density a state of equilibrium occurs whereby the relativistic decrease in mass equals the increase in mass by its gravitational action. The result is an adiabatic one whereby gravitational energy spent is compensated for by equally receiving more energy from distant stars.

This cosmic state of equilibrium is mathematically unique inasmuch as curved space relates to SRT in a special way. Consider a mile long rod that is relatively straight whereby the rod's own rotational period is the same as its orbital period. However, it is only straight if light initially moving tangent with the orbit stays tangent with the orbit. If light speed is slowed by the relativistic factor squared, then at a decrease to (½)c corresponds with an escaped velocity of (½)c:

$$c\left[1-\frac{2GM}{rc^2}\right]=c'=c\left[1-\frac{1}{2}\right]=\frac{1}{2}c$$

If the orbital speed is also (½)c, then $GM/r = (¼)c^2$ and $2GM/rc^2 = (½)c$. The orbital speed and the escape velocity become one and the same, such as to converge into a homogeneous spacetime of gravitational free space.

This result is explained further in a final chapter with regard to how it is possible our universe is only an observable portion of a multiverse.

QUANTUM ORIGINS

A key origin of the quantum is blackbody radiation. Formulae were derived to determine a relation between temperature and intensity of radiation that a body of mass can absorb and emit while in equilibrium with the forces of nature. Classical formulae for predicting results of experiment failed until a concept of the quantum was introduced. Understanding this development is with regard to particular relations between heat and light.

Heat and Light

In the year 1800, William Herchel (1738-1822) used a variety of glasses of different color lenses to peer through a telescope and observe the sun. By using these different glasses of various color, he discovered light filtered through some of them felt warmer than light filtered through others. He followed up with the implications of this discovery by devising experiments consisting of prisms and thermometers to further discover heat tends to be greater towards the red end of the light spectrum and even beyond into the hitherto unknown infrared part of it invisible to the eye.

A heat-light connection was thus established, but it would be another twenty years before Andre-Marie Ampere (1775-1836) suggested light and heat are only different aspects of the same process. A response to Ampere's suggestion came with Marcedonio Melloni (1798-1854) agreeing inasmuch as he believed both are waves propagating through media. He regarded light as the harmonious waves of æther, and he similarly regarded heat as radiant waves of caloric, but his experimental findings from 1833 to 1840 indicated no essential difference in wave properties of these two phenomena. To his credit, he did discover the refractive properties of thermal radiation.

More development followed from experiments by Jean Bernard Leon Foucault (1819-1868) and Armond Hippolyte Louis Fizeau (1819-1896) in confirming the wave properties of radiant heat. The experiments split rays of infrared light for them to superimpose and produce alternating bands of

hot and cold in analogy to the light and dark fringes of ordinary light. James David Forbes (1809-1861) then discovered heat polarizes similar to that of light, and he advanced the concept of a continuous radiation spectrum that later became essential to Maxwell's theory of electromagnetism. It followed that the unification of electromagnetism and thermodynamics was in order. It would have been routine except for the predominance of wave theory at the time. The relation between vibrant molecules of matter with the waves of light was not adequately understood as of yet.

There had been some attempts to unify theory as such. Leonard Euler (1707-1783) offered the principle a particular substance of mass is able to absorb light of any frequency with which its smallest particle vibrates. He attempted to explain phenomena according to the æther from which matter forms. His theory was not successful, but his absorbing principle did not go unnoticed.

More essential to the development of theory were discoveries of how matter absorbs light. William Wollaston (1766-1825) discovered in 1802, for instance, that light spectra emitted from matter include dark lines. Joseph Fraunhofer (1787-1826) made more discoveries along this line in 1814. The interest in these discoveries grew among physicists. Stokes, for one, used the principle of Euler to explain them as atoms absorbing light waves by a method of resonance.

Pierre Prevost (1751-1839) had provided evidence indicating all bodies radiate heat. The evidence suggested further that poor absorbers of heat are also poor emitters of it, whereas good absorbers are good emitters, and it became evident that a material in thermal equilibrium emits what it absorbs. In 1858, Balfour Stewart stated the law that the absorptivity of a material in a state of thermal equilibrium is equal to its emissivity. Stewart assumed the absorptive and emissive ability of different materials varies in relation to the nature of their substance, and Gustav Kirchhoff (1824-1887) proposed in 1859 a particular condition of "blackbody" radiation applicable to all bodies regardless of their material composition.

Kirchhoff examined the spectrum of sunlight after it passed through a sodium flame to discover that the dark D lines of the spectrum, as they are called, change to yellow when the sunlight is of low intensity, but that they are darker with more intense sunlight. He also found the sodium emits the same part of the light spectrum absorbed with an appropriate increase in temperature of the sodium flame. Kirchhoff thus surmised the ability of a substance to absorb and emit a certain color of light depends on its relative state of equilibrium. Further experiments to confirm this premise indicated the absorptivity and emissivity for a material is a function of its temperature and the wavelength, or frequency, of the light alone.

The mathematical formulation of the law assumes a system obtains a state of thermal equilibrium at sub temperature below incandescence. Thus, if A denotes total radiation per surface area on each body of mass, *a* the fractional amount of radiation actually absorbed by the mass, and E is the permissible radiation emitted from it, then the relations are mathematically expressed in the manner

$$aA = E \qquad A = \frac{E}{a}$$

For all materials in a state of thermal equilibrium, the powers of emissivity (E_1, E_2, E_3, etc.) divided by their respective factors of absorptivity (a_1, a_2, a_3, etc.) equal the same amount of light incident per surface area:

$$A = \frac{E_1}{a_1} = \frac{E_2}{a_2} = \frac{E_3}{a_3} \cdots = \frac{E_n}{a_n}$$

Kirchhoff defined the blackbody as one absorbing and emitting radiation of all frequencies or wavelengths. In this case, the power of emissivity of the blackbody is E_B, and the fraction of light absorbed is unity, $a_B = 1$, such that the following equation results:

$$\frac{E}{a} = \frac{E_B}{1}$$

Dividing by E_B, multiplying by *a*, changing order and assuming absorptivity equals emissivity obtains

$$a = \frac{E}{E_B} = \varepsilon$$

The symbols *a* and ε denote the absorptivity and emissivity, respectively, of a material body in ratio to a blackbody. Further relation is in view of the discovery of a fourth power law that is now commonly referred to as the Stefan-Boltzmann Law.

The Stefan-Boltzmann Law

The rate that a system changes from one temperature to another for obtaining a state of equilibrium with its environment is further significant. Newton had assumed the process is linear inasmuch as the rate of change in temperature is proportional to the difference between that of a system and its environment, but experiment indicated that this relation only holds true approximately at relatively normal temperatures, as the data did not appear linear at higher ones.

Another relation superseded Newton's in the late 19th century. It came from a study of temperature and light intensity by John Tyndall (1820-1893) and Joseph Stefan (1835-1893). Tyndall had run an electric current through a platinum wire that resulted in heating the wire to a state of incandescence. On measuring the radiation emitted at different temperatures, he found the intensity to be about twelve times as great with the wire being about 1200 degrees centigrade than if only 525 degrees centigrade. He calculated

$$\left[\frac{273°+1200°}{273°+525°}\right]^4 = \left[\frac{1473°}{798°}\right]^4 \approx 12$$

The 273° is the centigrade scale of 273° above absolute zero. The ratios are thus according to absolute zero.

This mathematical relation appeared the same for all substances at all temperatures. Stefan concluded the intensity I is proportional to the fourth power of the absolute temperature T:

$$I = k_B T^4$$

The constant k_B is named the Boltzmann constant. Its value is 1.3806503 x 10^{-23} J/K, which is 1.38065 X 10^{-16} grams multiplied by centimeters squared per seconds squared per one degree Kelvin. Because of such minuteness of the numerical value of the constant, a slight change in temperature, even to the 4th power, causes only a slight change in light intensity.

Tyndall's measurements were not very accurate. Modern results give a ratio of about 18 to 1, but Stefan's conclusion was based on a general study. Besides, Ludwig Boltzmann (1844-1916) later deduced this 4th fourth power relation, as valid for a blackbody only, in accordance with the second law of thermodynamics and Maxwell's theory of electromagnetism.

Entropy is conserved in compliance with the laws of thermodynamics by means of an adiabatic process, as in an extremely slow mechanical way to be reversible by means of a complete cycle. Denote the original state as S_1, as with an absolute temperature T_1, a volume V_1 and an energy density u_1 until it changes to state S_2 at absolute temperature T_2, volume V_2 and energy density u_2. The state S_2 can also change, in theory, to state S_3 at new volume V_3 while maintaining its same temperature and energy density by absorbing energy of an equal density and absolute temperature. The original temperature and energy density are restored at volume V_4 of state S_4.

The changes from state S_1 to state S_4 are exchanges of actual quantities of heat energy, such that they are interpretable in terms of work performed in changing from one state to another. The work energy performed during the adiabatic process is also consistent with Boyle's law. By it, the product of pressure p and volume V of a gas at a given temperature is constant:

$$pV = k$$

Pressure also relates in terms of force:

$$p = \frac{F}{r^2} \propto \left[\frac{mv^2}{r}\right] \cdot \left[\frac{1}{r^2}\right]$$

The pressure-volume product is thus maintained according to a centripetal force mv^2/r per area r^2. With pV in relation to a volume proportional to distance cubed, further relations result in the manner

$$pV = \frac{FV}{r^2} \propto Fr \propto FV^{\frac{1}{3}}$$

In view of Boyle's law, the relations become

$$F_1 V_1^{\frac{1}{3}} = F_2 V_2^{\frac{1}{3}} = k$$

This equality relates work performed of distance moved by a constant force for each event of a change in volume of a gas.

The energy density u of a proportional amount of radiation absorbed by a gas in thermal equilibrium is calculated as the force per volume. Hence

$$u = \frac{F}{V} \qquad F = uV$$

By substitution, the previous equations become

$$u_1 V_1 V_1^{\frac{1}{3}} = u_2 V_2 V_2^{\frac{1}{3}} = k$$

$$u_1 V_1^{4/3} = u_2 V_2^{4/3} = k$$

As for converting in terms of volume space, the square root of the square root of the cube of the equality is

$$u_1^{\frac{3}{4}} V_1 = u_2^{\frac{3}{4}} V_2 = k^{\frac{3}{4}}$$

As for relating to temperature, conditions of entropy are considered instead of the ideal gas law. Relating to the various states S_1 through S_4 gives

$$u_1^{\frac{3}{4}}V_1 = u_2^{\frac{3}{4}}V_2 = k_1^{\frac{3}{4}}$$

$$u_2^{\frac{3}{4}}V_3 = u_1^{\frac{3}{4}}V_4 = k_2^{\frac{3}{4}}$$

These values are for each state with regard to change in energy density per volume.

The following equation expresses conservation of entropy with regard to the second law of thermodynamics:

$$\frac{Q_2}{T_2} + \frac{Q_1}{T_1} = 0$$

Q_1 denotes a negative amount of heat liberated from a change of state S_4 to state S_2, and Q_2 denotes a positive amount of heat absorbed from a change of state S_2 to state S_3. These changes in heat are proportional to the amount of change in energy per change in volume. In terms of energy density and change in volume, they become

$$Q_2 = u_2(V_3 - V_2)$$

$$Q_1 = u_1(V_1 - V_4)$$

Hence

$$\frac{Q_2}{T_2} + \frac{Q_1}{T_1} = \frac{u_2(V_3 - V_2)}{T_2} + \frac{u_1(V_1 - V_4)}{T_1} = 0$$

However, in relation to Boyle's law and the constants for volume space, the following equations result

$$u_2^{\frac{3}{4}}V_3 - u_2^{\frac{3}{4}}V_2 = k_2^{\frac{3}{4}} - k_1^{\frac{3}{4}} \qquad u_1^{\frac{3}{4}}V_1 - u_1^{\frac{3}{4}}V_4 = k_1^{\frac{3}{4}} - k_2^{\frac{3}{4}}$$

$$u_2^{\frac{3}{4}}(V_3 - V_2) = k_2^{\frac{3}{4}} - k_1^{\frac{3}{4}} \qquad u_1^{\frac{3}{4}}(V_1 - V_4) = k_1^{\frac{3}{4}} - k_2^{\frac{3}{4}}$$

$$V_3 - V_2 = \frac{k_2^{\frac{3}{4}} - k_1^{\frac{3}{4}}}{u_2^{\frac{3}{4}}} \qquad V_1 - V_4 = \frac{k_1^{\frac{3}{4}} - k_2^{\frac{3}{4}}}{u_1^{\frac{3}{4}}}$$

Substituting the right-hand sides of these equations into the thermodynamic equation obtains

$$\frac{Q_2}{T_2} + \frac{Q_1}{T_1} = \frac{u_2(V_3 - V_2)}{T_2} + \frac{u_1(V_1 - V_4)}{T_1}$$

$$= \frac{u_2}{T_2}\left[\frac{k_2^{\frac{3}{4}} - k_1^{\frac{3}{4}}}{u_2^{\frac{3}{4}}}\right] + \frac{u_1}{T_1}\left[\frac{k_1^{\frac{3}{4}} - k_2^{\frac{3}{4}}}{u_1^{\frac{3}{4}}}\right]$$

$$= \frac{u_2^{\frac{1}{4}}}{T_2}\left(k_2^{\frac{3}{4}} - k_1^{\frac{3}{4}}\right) + \frac{u_1^{\frac{1}{4}}}{T_1}\left(k_1^{\frac{3}{4}} - k_2^{\frac{3}{4}}\right)$$

$$= \frac{u_2^{\frac{1}{4}}}{T_2}\left(k_2^{\frac{3}{4}} - k_1^{\frac{3}{4}}\right) - \frac{u_1^{\frac{1}{4}}}{T_1}\left(k_2^{\frac{3}{4}} - k_1^{\frac{3}{4}}\right) = 0$$

Hence

$$\frac{u_2^{\frac{1}{4}}}{T_2} - \frac{u_1^{\frac{1}{4}}}{T_1} = 0 \qquad \frac{u_2^{\frac{1}{4}}}{T_2} = \frac{u_1^{\frac{1}{4}}}{T_1}$$

Because energy densities and temperatures equal, the adiabatic cyclic change is constant, such that

$$\frac{u^{\frac{1}{4}}}{T} = k_B \qquad u = k_B T^4$$

Moreover, u is the energy density of the radiation of intensity I absorbed or emitted, as proportional to intensity of radiation incident on a blackbody. Although they express different aspects of energy, their results are of the same process. By substituting I for u, the equation $I = k_B T4$ expresses the mathematical interpretation of Stefan-Boltzmann's law.

Wien's Displacement Law

The Stefan-Boltzmann law relates temperature and radiation intensity, but it does not specify how a particular frequency or wavelength of light applies. Wilhelm Wien (1864-1928) determined a relation for the intensity of radiation for temperature and a particular range in the wavelength or frequency of the temperature. He discovered shorter wavelengths are more inclined to be emitted at higher temperatures. Sunlight, for instance, is more energetic with shorter wavelengths than radiant energy invisible to the eye.

For further analysis, Wien adopted the adiabatic concept with regard to blackbody radiation. However, a true blackbody is not available to study within the confines of a laboratory. Although soot is black, for instance, it still emits radiation invisible to the eye. Even so, blackbody conditions of equilibrium tend to occur with a slight change in the environment from its interaction with radiation. Although an oven allows radiation to escape, the oven temperature can still be maintained by means of using fuel. Wien thus considered a hollow container kept in thermal equilibrium, as by having a tiny hole at its surface to allow radiation to enter and reflect here and there on the walls of the container before it finally finds its way out.

Wien surmised a blackbody varies with a small range in wavelength of radiation at maximum intensity in inverse proportion to temperature. Thus, a shorter more frequent wave at maximum intensity correlates with a higher temperature such that Wien's displacement law is $\lambda_{max}T = b$, where b is a constant.

Relating the intensity of radiation along with both the temperature and wavelength is more complex. The total intensity is to the fourth power of temperature. To determine it according to any particular wavelength at any given temperature, the formula includes the three variables of wavelength, temperature and intensity. Since the total intensity is to the fourth power of temperature, and since the wavelength shortens per higher temperature, and because of such other considerations as with regard to the Doppler Effect, Wien eventually concluded that the intensity for a particular wavelength at a given temperature is to the fifth power of the wavelength.

To derive a formula, he related wavelength and temperature according to a distribution law derived by Maxwell for relating molecular speeds in a gas in relation to temperature:

$$dN = \left[\frac{m}{2\pi T}\right]^{\frac{1}{2}} \cdot e_x^{-\frac{1}{2}mv^2/k_BT}$$

Wien associated cavity radiation here with a molecular resonance, as wave frequencies in proportion to the kinetic energies of resonators. Identifying wavelength λ of the radiant energy with kinetic energy, $(½)mv^2 \approx kT \approx b/\lambda$, of the molecules, the exponential function $e_x \approx 2.718281828$ in Maxwell's formula is raised to a power in relation to kinetic energy, temperature and wavelength. As the function F(λ,T) of wavelength and temperature, Wien derived a formula for the intensity I_λ of a particular range of λ in relation to constants a and b in addition to k_B as

$$I_\lambda \cdot d\lambda = \frac{a}{\lambda^5} \cdot e_x^{-b/\lambda k_BT}$$

It fared well with data in relation to high frequencies, but not in relation to low ones.

Plank's Solution

Scientists had been aware from the mid 19th century that light escaping from an oven of higher temperature through a tiny crack is more energetic. Therefore, Ferdinand Kurlbaum (1857-1927) and Heinrich Leopold Rubens (1865-1922) experimented in observing waves as long as 59 microns, which is one twentieth of a millimeter. Wien's formula failed in predicting accurate results for these longer wavelengths.

When Rubens revealed the experimental results to Max Planck (1858-1947) in 1900, Planck had a solution the same day. He assumed resonators of radiant heat mediate between molecules and radiation, as by absorbing, storing and releasing the same particular quantity of radiant energy. Planck's solution to the problem was therefore to quantize energy as multiples of hf, wherefore h is now known as Planck's constant, and f is light frequency in relation to energy.

The amount of energy of an oscillator is according to the values of each energy level, which are 0, hf, 2hf, etc. Since some are zero, neither the energy level nor the spatial distribution is continuous. The distribution itself is determined according to an exponential function of the Boltzmann factor

$$e_x^{-E/k_B t}$$

To further develop Maxwell's statistical treatment of the kinetic theory of gases, Boltzmann had derived the probabilities in terms of the exponential function, and he also applied discrete energy levels to this function before an infinitesimal division among the actions of molecules. Planck proceeded likewise, but instead of allowing his oscillators to become infinitesimal, he assumed one of the discrete energy levels applies.

A number N of oscillators in an incremental range of frequency near f has various multiples of energy E = hf, including zero, and is the number n times each consecutive level of the probability distribution, as in accordance with

$$N = n + ne_x^{-hf/k_B T} + ne_x^{-2hf/k_B T} + \ldots$$

$$= n\left(1 + e_x^{-hf/k_B T} + e_x^{-2hf/k_B T} + \ldots\right)$$

The infinite series in the equation converges to

$$N = n\left(1 - e_x^{-hf/k_BT}\right)^{-1}$$

The total energy of all oscillators is

$$E = n(0) + n(hf)^{-hf/k_BT} + \ldots$$

$$= nhfe_x^{-hf/k_BT}\left[1 + 2\left(e_x^{-hf/k_BT}\right) + 3\left(e_x^{-hf/k_BT}\right)^2 + \ldots\right]$$

This infinite series converges to

$$E = nhfe_x^{-hf/k_BT}\left(1 - e_x^{-hf/k_BT}\right)^{-2}$$

Dividing E by N obtains

$$\frac{E}{N} = \frac{nhfe_x^{-hf/k_BT}\left(1-e_x^{-hf/k_BT}\right)^{-2}}{n\left(1-e_x^{-hf/k_BT}\right)^{-1}} = \frac{hfe_x^{-hf/k_BT}}{1-e_x^{-hf/k_BT}} = \frac{hf}{e_x^{-hf/k_BT}-1}$$

E/N represents the average energy per oscillator of incremental frequency range between f and (f + df) inasmuch as n factors out of the equation.

Comparing Formulas

In comparison to Wein's formula, Planck derived

$$I_\lambda \cdot d\lambda = \frac{2c}{\lambda^5} \cdot \frac{h}{e_x^{hc/\lambda k_BT}-1}$$

The only difference in it and Wein's formula is Wein's constants *a* and b are replaced with hc and a slightly different form of the exponential function. As for the number 2, twice hc is twice the change in speed c with regard to a reverse in direction for total distance.

The constant h relates dimensionally as a product of mass, velocity and distance, whereas the constant k_B is the product mass and velocity squared. Therefore, hc is dimensionally the same as λk_BT, such that they are of the same ratio no matter what are the units of mass, distance and time used to determine results. The exponential function thus changes only by the ratio of T, which is consistent with Wien's displacement law.

If c = λf, then replacing each λ with c/f obtains

$$I_f \cdot df = \frac{2f^5}{c^4} \cdot \frac{h}{e_x^{hf/k_BT} - 1}$$

However, textbooks give the frequency formula as

$$I_f \cdot df = \frac{2f^3}{c^3} \cdot \frac{h}{e_x^{hf/k_BT} - 1}$$

However, the result of using different formula for λ and f is that c ≠ λf.

The reason the results of these formulas do not equate is because they pertain to different forms of energy. One form is a modification of Wien's formula, and the other is from a formula derived by Sir James Jean (1877-1946) and John William Strutt (1842-1919), renamed Lord Rayleigh. Wien's distribution formula is in accordance with his displacement law for a change in temperature; the other formula was derived according to an equipartition theorem derived independently first by John James Waterston (1811-1883) and later by Maxwell and Clausius for advancing the kinetic theory of gases. It relates to degrees of freedom.

A degree of freedom is related according to the number of modes of vibrations. The same space is assumed to be more capable of containing a greater number of modes of shorter wavelengths. Rayleigh assumed there is a tendency for the shorter modes to dominate. However, the shorter waves are more energetic because of their more rapid vibrations, such as to result in an ultraviolet catastrophe from a tendency to increase to infinite energy. Such a result was considered in violation of conservation of energy, and the formula differs from the Stefan-Boltzmann fourth power law. The formula was thus in need of modification.

The modification resulted in a different relation of energy than Plank's formula. In Planck's original formula, change in wavelength λ relates in the manner

$$\frac{hc}{\lambda^5} = \frac{hf\lambda}{\lambda^5} = \frac{hf}{\lambda^4} = \frac{mc^2}{\lambda^4}$$

The change in radiant energy is thus per fourth power of wavelength. In the other formula, change in frequency f relates in the manner

$$\frac{hf^3}{c^3} = \frac{mc^2f^2}{c^3} = \frac{mc^2f^2}{c(\lambda^2f^2)} = \frac{mc}{\lambda^2}$$

There is thus change in momentum occurring per wavelength squared, as in contrast of internal energy of mass per wavelength to the fourth power.

QUANTUM PHYSICS

An early application of the quantum was the Bohr Theory of the atom. It was followed by the discoveries of the photoelectric and Compton effects. Further advance came with the development of Quantum Wave Mechanics as a relativistic quantum modification of Wave Mechanics whereby its wave equations, in turn, became reinterpreted as probability equations according to an Uncertainty Principle. Such new interpretation is now established with the evolution of Quantum Electrodynamics (QED), the quark model, string theory, Grand Unified Theories and so on. Although such development is complex, it can still be understood in light of a more simple theory of the Bohr atom in establishing fundamental relations of physical constants.

The Bohr Atom

Applying the quanta to the structure of the atom came from Niehs Henrik David Bohr (1885-1962). He modified the atomic model previously announced by Ernst Rutherford (1871-1937) in 1911, who had contrived a model of the atom to describe how alpha particles reflect. Accordingly, the bulk of mass that scatters is contained within a nuclear radius of about 1836 times smaller than the radius of the atom itself. Rutherford further assumed atoms continually absorb and emit radiation as electrons accelerate around the nucleus. However, his model failed to accurately predict phenomena.

One such phenomenon pertains to the spectra of radiation emitted by atoms. The spectral lines of light associated with atoms did not conform to a pattern consistent with a known theory of continuous spectra. Formulae had been provided apart from theory, as in 1885 by Johanne Jakob Balmer (1825-1890), and the later experiments by Johannes Robert Rydberg (1854-1919), Carl Runge (1856-1927), and Henrich Kayser (1853-1910). Their *ad hoc* formulae agreed for the most part with observations, but they lacked a theoretical foundation until Bohr proposed, in 1913, quantum restrictions for his modified version of Rutherford's atomic model.

Bohr assumed electrons orbit the nucleus of an atom in elliptical paths whereby atoms either emit or absorb radiation only when the electron state of angular momentum changes in multiples of h/2π.

Bohr only modified classical formula by applying quantum restrictions, as in assuming a force field exists consistent with Coulomb's inverse square law for electrostatics and magnetism. An electron thus has a negative unit of charge e and a nucleus has a positive unit of charge e. The force between them is the product of charge per distance r squared:

$$F = \frac{e}{r} \cdot \frac{-e}{r} = \frac{-e^2}{r^2}$$

In comparison, Newton's second law of motion for centripetal force gives

$$F = \frac{-mv^2}{r}$$

Equating the right sides of the last two equations and dividing them in half obtains

$$\frac{-e^2}{2r^2} = \frac{-\frac{1}{2}mv^2}{r}$$

$$K = \frac{e^2}{2r} = \frac{1}{2}mv^2$$

It thus relates to classical formula for kinetic energy K of the electron.

The potential energy T of the electron, as within a conservative field of force, is

$$T = \frac{-e^2}{r}$$

The total energy W is therefore

$$W = K + T = \frac{e^2}{2r} - \frac{e^2}{r} = \frac{-e^2}{2r} = -\frac{1}{2}mv^2$$

The last two equalities give

$$\frac{-e^2}{2r} = -\frac{1}{2}mv^2 \qquad r = \frac{e^2}{mv^2}$$

The orbital radius of the electron is the unit of charge squared per twice the kinetic energy of the electron.

Bohr assumed the total energy W becomes zero as r becomes infinite, or whenever the atom becomes ionized because of it losing an electron. By applying quantum restrictions to the atomic radius in using the relations nħ = nh/2π = n (mvr) and $e^2 = mv^2r$, he deduced

$$r = \frac{e^2}{mv^2} = \frac{e^2n^2\hbar^2}{m^3v^4r^2} = \frac{e^2n^2\hbar^2}{me^4} = \frac{n^2\hbar^2}{me^2}$$

The letter m represents the mass of the electron, ħ is the Planck constant h divided by 2π, and n is an integer from one to infinity.

The respective velocity of the electron around the nucleus is

$$v^2 = \frac{e^2}{mr} = \left[\frac{e^2}{m}\right] \cdot \left[\frac{me^2}{n^2\hbar^2}\right] = \left[\frac{e^2}{n\hbar}\right]^2$$

$$v = \frac{e^2}{n\hbar}$$

$$\frac{v}{c} = \frac{e^2}{n\hbar c} = \frac{\delta}{n}$$

$$\delta = \frac{e^2}{\hbar c} \approx \frac{1}{137}$$

The fraction (1/137) is the fine structure constant here denoted as δ.

Bohr further recalculated the energy to eliminate r from the equations. Previous equations give

$$E = -\frac{1}{2}mv^2 \qquad v^2 = \frac{e^4}{n^2\hbar^2}$$

Multiplying both the numerator and denominator by c^2, and substituting δ^2 for $e^4/\hbar^2c^2$, obtains

$$E = \frac{1}{2}\frac{me^4}{n^2\hbar^2} = \left[\frac{\frac{1}{2}mc^2}{n^2}\right] \cdot \left[\frac{e^4}{\hbar^2c^2}\right] = \frac{-\delta^2\left(\frac{1}{2}mc^2\right)}{n^2}$$

The highest energy level is n = 1 electron, such that

$$E = -\delta^2\left(\frac{1}{2}mc^2\right)$$

Bohr's next assumption was the atom is able to obtain a lesser energy level by emitting a photon of energy E – E', the difference of the energy levels.

This energy, as for a general formula predicting light spectra emitted from atoms, relates to the frequency f of the photon by the equation

$$E - E' = hf = \frac{1}{2}\delta(mc^2)\left[\frac{1}{n^2} - \frac{1}{n'^2}\right]$$

A stipulation applies here for n = 1, and for n' to only be any integer greater than one, as for an atom to either decrease or increase from an energy level to another by either absorbing or emitting a photon of energy hf.

The Photoelectric Effect

Planck interpreted the nature of the quantum as a molecular oscillator, but Einstein interpreted it as applying to light as well as to the oscillators in explaining a photoelectric effect that was discovered in 1902 by Phillepps Lenard (1862-1947). Lenard discovered the result of electrons emitted from a metal due to light shining on the metal depends more on the frequency of light than its intensity. No electrons are emitted if the frequency is too low and at a sufficient frequency electron velocities depend on light frequency. Only the number of emitted electrons depends on light intensity.

Einstein interpreted Lenard's findings according to Planck's quantum condition of energy being discrete multiple units of hf. Light quanta (now called photons) therefore collide with a metal such that the energy of each photon transfers to an electron for the electron to break loose its bondage with the metal. The energy E of the particle of light is thus called a photon.

Although the electron only absorbs a particular quantum of light, the possible energy of light is still continuous along with energy of matter with regard to relative motion. The continuousness of light energy is associated with varying wavelength λ and varying frequency *f* with regard to how they interact with matter according to the Doppler principle of relative motion. The quantum relation h*f* increased by a relativistic factor for relative motion of matter, for instance, allows continuous energy of light to correspond to continuous energy of matter in relative motion such that more intense light reflected by matter can increase thermal temperature and kinetic energy, but the ejection of electrons is still determined by the quantum states of matter and light.

After determining a numerical value for the fundamental charge of the electron, Robert Andrews Millikan (1868-1953) was able to verify Einstein's explanation of the photoelectric effect as well. His experiment was that of a statistical nature in measuring the electrical voltage of electron emissions in comparison to light intensity on a metal screen. It produced a photon to electron emission in accordance with the light energy needed of a particular frequency. In 1915, Millikan's controlled experiments were able to interpret

the data in a way it not only convincingly verified the photoelectric effect, it confirmed the value of Planck's constant as well.

The Compton Effect

Similar to the photoelectric effect is the Compton Effect that includes a redirection and loss of photon energy as well as an ejection of electrons from atoms. However, only reflection between light and free electrons apart from containment, such as by a metal, are observed. In explaining statistical results of photon and light interaction, Arthur Holly Compton (1892-1962) assumed light and electrons are particle-like. Thus, the laws of conservation of energy and momentum apply to statistical results for equating with a loss of energy of photons, as according to their angle of deflection, and the gain in energy of electrons recoiling in opposite directions.

In 1922 Compton bombarded graphite with x-rays in examining how x-rays scatter electrons. He discovered their angle of scattering is consistent with conservation of momentum. The momentum of a scattered electron at a particular angle of a scattered electron coincides with a loss in momentum of the scattering x-ray and its recoil angle, as according to a Doppler shift to a longer wavelength. In manner of conservation of momentum, a change in the wavelength of an x-ray after it collides with an electron is

$$\Delta\lambda = \lambda' - \lambda = \frac{h}{m_e c}(1 - \cos\theta)$$

With straight ahead collision the cosine angle is unity such that 1 – 1 = 0, as zero change in wavelength. Since the right angle reflection is a zero degree cosine angle, the Compton wavelength for the electron is

$$\lambda_C = \frac{h}{m_e c} = 2.43 \times 10^{-10} \ \ centimeters$$

For a 180° degree reflection, the cosine angle is minus unity, as for a change in wavelength that is twice the Compton wavelength.

The Compton wavelength λ and frequency f represent properties of a photon moving at speed c. For interacting with an atomic particle, they also relate to a quantum h of energy and mass m relatively at rest in the manner

$$E = hf = \frac{hc}{\lambda} = mc^2$$

(There is also a common use of a reduced Compton wavelength as λ/2π. It refers to a limited measure of position according to a probability condition of Quantum Mechanics.)

Wave Mechanics

William Rowan Hamilton (1805-1865) formulated wave mechanics to combine wave properties with particle interaction. He noticed a similarity in form in mathematical formulations of the principles of least time and least action. Pierre de Fermat (1601-1665) offered the principle of least time as a means to describe a light path. The least action principle was formulated by Pierre Louis Moreau de Maupertis (1698-1759) for describing the dynamics of interaction between particles.

Properties of various physical media for the propagation of light waves are according to their refractive indices, as defined by the equation

$$\mu = \frac{c}{v}$$

The Greek letter μ denotes the refractive index of the particular medium, c is the light speed in vacuum space (or æther), and v is light speed through a physical medium such as glass or air. The refractive index for vacuum space or æther is unity, and it is greater for other media. Since c is constant, and since μv = c, the speed of light is slower in a refractive index greater than one. The slower speed is justified by conservation of momentum since the wave increasing in inertia as part of the denser medium compensates for the wave propagating the momentum of more mass at a slower speed. A denser medium of mass thus becomes, in part, light. (Matter or mass could actually be a denser part of the medium maintained in particular manner of emitting and absorbing a particle form of radiation while either reflecting or moving through all other radiation in a particular state of equilibrium.)

Fermat's principle of least time is according to the relation where time along the total path from point A to point B at each increment of distance ds through a medium of refractive index u is

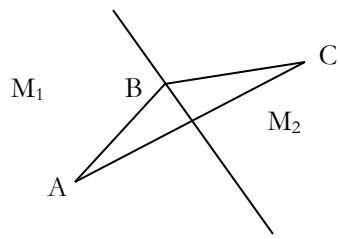
$$\int_A^B u \cdot ds$$

A particular requirement of this integral is it needs to be an extremum, as either a maximum or a minimum value. The value of least time comes by way of associating u with c/v, such that the greater u results in a slower v for more time.

The significance of this integral with regard to the law of refraction is in realizing a total path that light takes through two media of two different indices. The path from A to B through the first medium, and from B to C through the second medium, needs to be a minimum for the total time. The least time does not mean the shortest path; rather, it depends on the angle

of entry. The shortest path is a straight line from A to C, but the time along this path is greater for the medium having a greater refractive index. If the angle of entry is from a shorter path of the medium of a greater index, then the time can be less in the new and longer path. The law of refraction also expresses this result. The least time principle is thus according to the law of refraction in view of wave theory.

A straight line is shorter from point A to point C, but the path from point A to point B to point C is faster because of the shorter distance from point B to point C in the denser medium, M_2.



The principle of least action is similarly expressed as

$$\int_A^B mv \cdot ds$$

Momentum mv replaces refractive index μ of the medium. An increment of distance ds along some path from A to B thus has the momentum mv for action. For the total path from A to C through two media of two different indices of reflections, the same condition exists for less action as it does for less time. The least action principle thus determines the path of a particle in a conservative field of force in the same manner the principle of least time determines the path of the light wave. A conservative field of force is one in which the total energy, as potential and kinetic, stays the same.

The Hamiltonian Action is a formulation of Least Action in view of a conservative field of force. By way of a homogeneous medium of constant force, total action is simply the product of a particle's momentum mv and its distance r. Total energy at any increment of the distance before, during, or after a particle passes is the potential energy of a field in association with the particle in addition to its kinetic energy of relative motion. For constant field energy, Hamilton distinguished between the action of the particle and the total field energy as varying in time and place. The Hamiltonian Action A thus takes the form

$$A = S - Et$$

E denotes a total energy, t is the time of action, and S is the Maupertuisian Action mvr.

Anywhere along the path of the particle, or along the crossing of paths of a swarm of particles, the action varies with time. At any place where the action is zero are the relations

$$Et = mvr$$

$$\frac{E}{mv} = \frac{r}{t} = v$$

The total energy per momentum is thus the velocity of the field.

Hamilton's Wave Mechanics are significant in describing the evolution of waves as multiple interactions of particles and manifestations of particles in an association with wave packets. A mathematical theory of wave packets was later developed by Lord Rayleigh. It foreshadowed the wave mechanics of de Broglie and Schrodinger that included Planck's constant h.

The discovery of the quantum along with the success of wave theory for describing the behavior of light indicates light has a dualistic nature. It behaves partly as a particle and partly as continuous waves. Louis de Broglie (1892-1987) further theorized the nature of matter as a particle-wave duality as well with regard to his formulating theory according to special relativity, wave properties and the quantum. Accordingly, energy E and momentum P of a particle moving freely in space relate to the number σ of waves having frequency f and wavelength λ equate with Planck's constant h in the manner

$$E = mc^2 = \frac{m_o c^2}{\sqrt{1-\beta^2}} = hf$$

$$\vec{P} = m\vec{v} = \frac{m_0\vec{v}}{\sqrt{1-\beta^2}} = \frac{hf}{\vec{V}} = \frac{h}{\vec{\lambda}} = h\vec{\sigma}$$

The arrows indicate the waves and particles move in the same direction.

Capital V denotes the velocity of the waves. As with waves in general, it equates to the product of their wavelength λ and frequency f as

$$V = f\lambda$$

This relation in relation to momentum and energy equates as

$$V = \lambda f = \left[\frac{E}{h}\right] \cdot \left[\frac{h}{P}\right] = \frac{E}{P} = \frac{mc^2}{mv} = \frac{c^2}{v}$$

The case of photons moving at speed c gives

$$V = \frac{c^2}{v=c} = \frac{c^2}{c} = c$$

Since special relativity stipulates no information of events can exceed light speed in vacuum, the de Broglie waves carry no momentum or energy for them not to transmit immediate effect, but they are significant inasmuch as De Broglie interpreted particle effects as superimposed waves in analogy to the beats of sound produced by the superimposing of airwaves of certain numerical ratios. Waves supposedly form into wave packets where slightly faster moving waves overtake slightly slower ones for a particle effect. The velocity of the packet as a whole is that of the particle, which is slower than some of the waves.

How a packet maintains intact is somewhat of a mystery. The slightly faster moving waves inevitably continue forward to spread apart from the slower waves. Because new waves need to somehow add to the packet, the superimposing of de Broglie waves could further cause new disturbances of the medium for its generation of new waves. However, the creation of new waves needs to be offset with the annihilation of old ones in order for there to be no indefinite increase in the number of waves. As waves continually spread apart, their physical energies dissipate but maintain conservation by means of new waves generated. This process thus assumes the wave packets maintain in a state of equilibrium with the medium, as being consistent with the principle of envelops put forth by Huygens to explain light propagation, and also with regard to matter as a system maintaining a state of equilibrium with radiant energy and the æther.

Schrodinger's Wave Equations

De Broglie's ideas were refined by Erwin Schrodinger (1887-1961) in formulating them according to Wave Mechanics. De Broglie had associated such wave properties as frequency and wavelength with particle effects, but he did not offer a wave equation. Schrodinger formulated de Broglie's ideas according to a wave equation such that such wave properties as diffraction, refraction and polarization can be included in the analysis.

Schrodinger transformed the mechanical properties of momentum and energy into a particular wave equation containing the property of the quanta denoted by Planck's constant h. He commenced with a wave equation that had previously been derived by Jean le Rond d' Alembert (1717-1783), as to describe the vibrations of a string:

$$\frac{\partial^2 u}{\partial^2 x} + \frac{\partial^2 u}{\partial^2 y} + \frac{\partial^2 u}{\partial^2 z} = \frac{1}{V^2}\frac{\partial^2 u}{\partial t^2}$$

This wave equation describes velocity V in an isotropic and homogeneous medium of elasticity μ in four dimensional spacetime coordinates (x,y,z,t). The symbol ∂ denotes a partial differential. For any coordinate direction r, the wave equation relates in the manner

$$\frac{\partial^2 \mu}{r^2} = -\mathrm{V}^2 \sin(r - Vt) - \mathrm{V}^2 \sin(r + Vt)$$

$$\frac{\partial^2 \mu}{\partial r^2} = \frac{1}{V^2}\frac{\partial^2 \mu}{\partial t^2}$$

The significance of the wave equation is that it can be used to describe internal properties of mass-energy in complex ways. According to classical theory, wave properties relate to a conservative field of force with regard to its total kinetic and potential energies. As waves they are used as operators. De Broglie had related such quantities in the manner W = hf as energy and V = W/P as a wave velocity in relation to the velocity of matter. Hence

$$\frac{v^2}{V^2} = \frac{P^2}{h^2} = \frac{2m\left(\frac{1}{2}mv^2 - \frac{1}{2}mv^2\right)}{h^2} = \frac{2m\left[K - E_{pot}(x,y,z)\right]}{h^2}$$

K = (½)mv² is the kinetic energy of the particle, and $E_{pot}(x,y,z)$ = (½)mw is the potential energy of the field at coordinate point x,y,z where the particle is located at that particular moment.

The last equation equaling zero is significant as a boundary condition for describing internal conditions more intricately in view of a conservative field of force. By substituting the right-hand side of the equality in the wave equation, it becomes

$$\nabla\psi + \frac{8\pi^2 m}{h^2}\left[k - E_{pot}(x,y,z)\right]\psi = 0$$

The wave equation interprets momentum and energy of classical mechanics. A slight modification is thus in order for a relativistic wave equation.

Since both Schrodinger and de Broglie interpreted V according to the refractive index μ of a medium or field of force, hence

$$V = \frac{c^2}{v} = \frac{c}{\mu}$$

Considering the medium as a field of force generated by the nucleus of the hydrogen atom, energy E of the orbiting electron at coordinate point x,y,z relates to the refractive index in the manner

$$\mu^2 = \frac{[E - E_{pot}(x,y,z)]}{E^2}$$

The energy E is the energy of the electron. The field $E - E_{pot}(x,y,z)$ is the total energy minus the potential energy at coordinate point x,y,z.

Schrodinger's wave equation with quantum restrictions reinterprets the quantum conditions of the atom that was previously given by Bohr. Bohr had postulated a correspondence principle for including a wave condition where needed. Bohr's model further describes electrons circling the nucleus of the atom as being corpuscular in nature, whereas Schrodinger considered electrons as a diffused cloud whereby quantum restrictions result as certain nodal points of de Broglie standing waves. The significance in Schrodinger's approach is that Bohr's theory only explains refractive properties of atomic spectra as arising from an electron's change of orbit from one closer to the atomic nucleus than from one at the outer shell, whereas a greater refractive index μ closer to the nucleus of an atom according to Schrodinger's wave interpretation explains why there is also a greater nuclear attraction.

Spin and Antimatter

Schrodinger's wave equation in relativistic form explains nearly all the conditions of light spectra that Bohr's theory explains except for one that became explained with the *ad hoc* assumption of spin. A particular spectrum is explained by Bohr's theory with the assumption of the magnetic moment of the electron being defined by its own spin, as defined as half the value of the quantum constant h. Nowadays it is said the electron has a spin of ½, but the spin is symbolic in concept insofar as it does not compare with the spin of a ball.

George E. Uhlumbeck (1900-1988) along with Samuel A. Goudsmit (1902-1978) proposed a spinning electron to correct certain inadequacies of Bohr's theory to describe more fine spectra detected from the hydrogen atom. Although it allows for a spinning electron, there is no reason for it, but Wolfgang Pauli (1900-1958) showed electron spin is consistent with a wave equation presented in the form of a matrix. The matrix allows for the splitting of the wave equation for it to represent an electron spin in either of two directions. When combined with the amplitude function ψ of waves, it further suggests polarization.

Charles Galton Darwin (1887-1962) then derived a wave equation that includes a polarization effect of the spinning electron in describing the fine structure of the hydrogen atom by means of a wave equation. Neither Pauli

nor Darwin, however, derived wave equations from wave theory. This task was taken on by Adrien Maurice Dirac (1902-1984) in order to modify the relativistic form of Schrodinger's wave equation.

Schrodinger had used alternate ways to derive wave equations for both classical and relativistic forms. For the classical form, the kinetic energy K and momentum P are related in the manner

$$\frac{1}{2m}\left(P_x^2 + P_y^2 + P_z^2\right) - K = 0$$

Schrodinger replaced momentum-vectors P_x,P_y,P_z with respective operators

$$\frac{h}{2\pi i}\frac{\partial}{\partial x} \quad , \quad \frac{h}{2\pi i}\frac{\partial}{\partial y} \quad , \quad \frac{h}{2\pi i}\frac{\partial}{\partial z}$$

In addition, he replaced the energy K with the operator

$$-\frac{h}{2\pi i}\frac{\partial}{\partial t}$$

These replacements obtain equivalence in waveform.

The operators are first derivatives, as linear, and they apply to matrices Dirac formulated, but the relativistic form of the energy equation requires a more complex solution for including SRT conditions of combining energy with momentum in the form of the invariant

$$E^2 = P^2c^2 + m_o^2c^4$$

In the form of vector coordinates, the invariant is

$$P_x^2 + P_y^2 + P_z^2 + m_o^2c^2 - \frac{E^2}{c^2} = 0$$

Even though the energy W is equal to the square root of $P_x^2 + P_y^2 + P_z^2 + m_0^2c^2$, how the equation on its left side individually relates is not obvious. Schrodinger merely replaced W^2 with operators of a second derivative. The result, however, turns out to be inconsistent with matrices Dirac developed. Dirac thus opted to split the energy equation in its vector form into two to apply operators of the first derivative for each half.

It is possible to split the equation into two factors by ordinary algebra:

$$\left[\frac{E}{c} + \sqrt{P_x^2 + P_y^2 + P_z^2 + m_o^2c^2}\right] \cdot \left[\frac{E}{c} - \sqrt{P_x^2 + P_y^2 + P_z^2 + m_o^2c^2}\right]$$

$$= \frac{E^2}{c^2} - P_x^2 - P_y^2 - P_z^2 - m_o^2 c^2$$

The next step is to operate on each factor individually to obtain first order derivatives for each. However, a problem with partial differentiation arises because P_x, P_y, P_z and m_0c are independent variables that are not obtainable as a square root of the sum of the squares.

To split the equation in order to obtain a wave equation in a standard form, Dirac applied the non-commutative rule in the manner

$$\left[\frac{E}{c} - \alpha_x P_x - \alpha_y P_y - \alpha_z P_z - \beta m_o c\right] \Psi = 0$$

The symbols α_x, α_y, α_z, β are coefficients independent of momentum, energy and time coordinates.

Multiplying the factor in the bracket by the factor $(E/c + \alpha_x P_x + \alpha_y P_y + \alpha_z P_z + \beta m_0 c)$ obtains

$$\left[\frac{E^2}{c^2} - \alpha_x^2 P_x^2 - \alpha_y^2 P_y^2 - \alpha_z^2 P_z^2 - \beta^2 m_o^2 c^2\right.$$

$$-(\alpha_y \alpha_z + \alpha_z \alpha_y) P_y P_z - (\alpha_z \alpha_x + \alpha_x \alpha_z) P_y P_z$$

$$-(\alpha_x \alpha_y + \alpha_y \alpha_x) P_x P_y - (\alpha_x \beta + \beta \alpha_x) m_o c P_x$$

$$\left.-(\alpha_y \beta + \beta \alpha_y) m_o c P_y - (\alpha_z \beta + \beta \alpha_z) m_o c P_z\right] \Psi = 0$$

The following relations apply:

$$\alpha_x^2 = \alpha_y^2 = \alpha_z^2 = -\beta^2 = 1$$

$$\alpha_y \alpha_z + \alpha_z \alpha_y = 0 \ , \ \alpha_z \alpha_x + \alpha_x \alpha_z = 0 \ , \ \alpha_x \alpha_y + \alpha_y \alpha_z = 0$$

$$\alpha_x \beta + \beta \alpha_x = 0 \ , \ \alpha_y \beta + \beta \alpha_y = 0 \ , \ \alpha_z \beta + \beta \alpha_z = 0$$

Relations as $\alpha_x \beta = -\beta \alpha_x$ are defined as non-commuting variables.

Of particular significance to the non-commuting rule is its compliance with the number i as the square root of –1. In ordinary algebra, the number one can either be $(1)^2$ or $(-1)^2$. The symmetry of Dirac's matrices, however, is such that $i^2 = -1$ has a unique interpretation: For every positive solution there is a negative or an imaginary solution as well. In reference to particle effects of electrons, for instance, the positive and negative factors represent

opposite directions of counterclockwise or clockwise electron spin, and for antimatter to exist as a negative state of matter.

This indication of antimatter is a square root of the momentum-energy equation being either positive or negative. It need not necessarily be either, as positive numbers each squared and added as such have only a positive value for the square root of their summation, but Dirac's matrices are of a symmetry consistent with the interpretation of Schrodinger's equations by Bohr, Born and Heisenberg whereby the wave aspect merely represents the probability of existence as predicted. Dirac's theory is thus verifiable as a test of predicting the positive and negative symmetry of nature. The theory has hitherto been a total success in this regard.

Probability Interpretation

Leading physicists as Max Born (1882-1970), Werner Karl Heisenberg (1901-1976), and Niehs Bohr reinterpreted Schrodinger's wave equations as probability equations. Born proposed the wave packet associated with the intensity of the action is the probable whereabouts of a particle. Heisenberg and Bohr then associated both waves and particles as representative of the probability function.

Born first reinterpreted Schrodinger's theory. What Schrodinger had proposed is a cloud of negative charge in place of Bohr's original model of the particle circling the nucleus of the atom. For instance, in the hydrogen atom, which consists of one electron, as one unit of charge, the total charge of the electron cloud, as Schrodinger had envisioned, is –e. In addition, he proposed the product of charge and an equilibrium state of wave intensities, as the product of amplitudes ψ_n and ψ_n^*, equals its energy density ρ at any point dxdydz when the energy of the atom is in a stable state:

$$\rho = -e\psi_n\psi_n^*$$

The product $\psi_n\psi_n^*$ is proportional to the wave intensity. It is used instead of ψ_n^2 in order to allow their product to be negative for a positive density– being that a negative density in the natural world is incomprehensible.

Representation of a total effect over infinite space is by integrating the point-charge-density in accordance with coordinate point dxdydz. However, total charge of the cloud is still only

$$-e \iiint \psi_n\varphi_n^* dxdydz = -e$$

$$\iiint \psi_n\psi_n^* dxdydz = 1$$

A proportion of the charged cloud therefore condenses at one moment to a specific and stable location dxdydz.

Heisenberg and Bohr interpreted the condition according to principles of uncertainty and complementarity. They found it difficult in view of the particle-wave paradox to conceive of a single particle obeying interference of two wave patterns after they pass through only one of two holes. They preferred instead to view the particle as a sort of diffused cloud capable of interfering with itself, or as consolidating into a particle-like form in that the nature of particle-wave effect is neither wave nor corpuscular in an ordinary sense; it manifests instead as certain observable effects of whatever it is that causes them to appear as such. A diffused cloud represents the effect when less observed; a tinier, more precise wave packet represents the effect when observed more accurately.

Although Schrodinger depicted the diffused cloud of negative charge as well, the depiction by Heisenberg and Bohr differed as according to their own view of the electron, or of any other atomic particle, inasmuch as they interpreted wave equations as probability equations determining probable energy and probable location of the particle effect to be observed.

An explanation of the probability condition could be it is because total energy moving through space is greater than what is actually observed. The observable secondary effects of nature, as Gassendi had proposed centuries earlier, could arise from the primary unobservable source underlying nature. However, without means of verification, the explanation is not science; it is speculation. Nonetheless, by the probability conditions of quantum physics suggesting an existence of a virtual field of virtual particles, the philosophy of Gassendi is worthy of consideration for a more complete understanding regarding wave-particle duality and physics in general.

Uncertainty

Heisenberg established a principle of uncertainty in order to determine the probability of finding the location or time of a particle effect from the probable outcome of its momentum or energy, respectively. According to Born's interpretation of Schrodinger's equations, a wave packet defines the region where a particle is locatable. The probability of the particle's position is at any particular point within the wave packet where it is proportional to the product of the total volume of the wave packet and its relative intensity. The relative size of the wave packet is dependent on the means by which it is observable, as by the ability of a photon to penetrate a certain level within the wave packet. Photons having higher frequency, greater momentum and more energy determine a smaller wave packet for a more precise location of the particle. As to the contrary, however, is the composition of the wave packet being of various waves slightly differing in their frequencies, speeds

and directions according to the magnitude of the photon's impact. A more compact wave packet collides with a more energetic photon to spread more rapidly, thus causing more uncertainty of its location whereas a photon with less energy spreads the wave packet less in time for the determination of its particle location as more precise.

Heisenberg's uncertainty principle follows from how Born viewed the wave packet. By Born, any one of the waves in the packet is representative of a probable particle of particular momentum and energy according to the range in energy by which waves vary. The causes of their spreading apart by impact of the photon, and by the difference in energies of waves, render the momentum and energy more uncertain. In following this lead, Heisenberg surmised more exact determination of the particle's position or time by the less energetic photon causes more uncertainty of the particle's momentum and energy. Conversely, the determination of momentum and energy by the more energetic photon causes more change in position to render its place in time as more uncertain. The total uncertainty is a product of uncertainties. The product of uncertainties of position and momentum, or the product of the uncertainties in time and energy, is the total uncertainty.

The relative momentum of the photon in relation to wave parameters and Planck's constant h is provided in relation to the equation $P = h/\lambda$. The uncertainty of the change in momentum ΔP with regard to the wavelength of the photon is opposite to the uncertainty of its change in position Δx. Certainty of position is uncertainty of momentum; conversely, certainty of momentum is uncertainty of position. Therefore, a range of positions for each momentum and a range in momenta for each position exist. The total uncertainty is the product

$$(\Delta x)(\Delta P) \geq \lambda(h/\lambda) = h$$

Total uncertainty further includes energy and time. The dimensions of h (as mass-velocity-distance or mass-distance squared per time) can also be interpreted as the product of distance and momentum (mass multiplied by distance and velocity) or as the product of time and energy (time multiplied by mass and velocity squared):

$$(\Delta t)(E) \geq h$$

This probable uncertainty is not interpreted the same as is that of flipping a coin. The coin can come up heads 3 times and tails 7 times after 10 tosses. After a million flips the heads-tails ratio is more apt to approximate as 1. In contrast, the probability of quantum physics is an exact prediction. If there is a probability of a particle showing up 3 times out of 10, then it does so as

predicted. It can show up 1 time for the first 8 observations, 1 time for the 9th observation, and 1 time for the 10th observation, or otherwise, but it is predicted to show 3 times in any combination of 10 observations.

A particular result of the Heisenberg Uncertainty principle is a virtual field of virtual particles. Such atomic particles as electrons surrounded by an electromagnetic field interact with it in creating additional particle effects. A particle interaction occurs with electrons emitting and absorbing, or merely reflecting, virtual photons according to a Feynman diagram describing their paths. Some intermediate virtual particles move faster than light, as allowed of de Broglie waves. Within minute times spans energy and momentum are not conserved, but positive and negative states of energy eventually balance out. A virtual photon can thus turn into a virtual electron-positron pair and vice versa. However, the virtual particles are short lived and are not directly detected, as they merely affect the measure of physical quantities according to the Heisenberg Uncertainty principle.

PLENUM COSMOLOGY

Explaining the underlying nature of the universe by means of the æther has been discarded by mainstream physics in favor of explaining only what can be observed. Still, however, the constant nature of light speed is explainable as contraction of length in the direction of relative motion and the retarding of clocks by motion through the æther in nullifying the differences of time and distance of measure at absolute rest. Perhaps the æther can still be used to explain the underlying nature of gravity, energy, mass and so on.

Any explanation of gravity that is not empirically verifiable is deemed invalid, but some of us still prefer to understand reality in a more complete manner. Explaining the cause of gravity in a manner consistent with other theory, for instance, might provide further insight for more development of theory. In any case, gravity is here explained in a manner consistent with the equivalence of gravitational and inertial mass, the probability conditions of quantum physics, and the conservation laws of momentum and energy, as to how the action can continue forward to change momentum of mass time after time, and as to how a continuous creation of gravitons does not fill up more space. Such explanation does not support all of established theory, as it is here explained as consistent with tired light theory rather than big bang theory, but this does not mean big bang theory is discarded in favor of the other. They can still be complementary aspects of reality.

Explaining gravity is relatively simple inasmuch as a gravitational force entails an attraction in proportion to mass, and in inverse proportion to its distance squared. More complex to explain is electric charge, as for entailing both attraction and repulsion. Electrons repel other electrons and protons repel other protons, but electrons and protons attract each other by equal amounts of opposite charge, even though the proton is about 1836.15 more massive than the electron. However, electric currents moving through wires moving in the same direction attract, whereas they repel if they are moving in opposite directions.

Electric currents that move through wires that loop in parallel circles produce a magnetic field. A change in the magnetic field, as by a change in its distance from a wire, induces an electric current through the wire, which induces a magnetic field and so on for electromagnetic induction resulting in the generation of alternating electrical current. Similar effects occur apart from wires. According to Alfven's theory, for instance, electric currents that move through filaments of plasma also attract and repel. An explanation of electric charge in comparison to gravity is thus more complex, but both of them are here explained in similar and consistent manner in reference to an æther filled plenum.

Circular Motion, Change and Reality

There is no room within a plenum for variable density, and there is no place for something in it to move to unless the motion is circular. Circular motion of various size and speed is possible. Changes in the various forms of circular motion are the results of our perceptions of the natural world.

A change in circular motion can occur in various degrees for a transfer of momentum if an underlying structure is in place to allow momentum to propagate as waves of energy not changing in density, as they only change in size, speed and other aspects of relative rotation. One possible structure for change is standing waves in states of equilibrium momentarily changing for each changed state to propagate at the same rate onto another standing wave and so on in a particular direction. This transfer of the deformed wave is to be perceived as the momentum of its influence. Its extended influence is what becomes perceivable as mass-energy, light, matter, and so forth.

A clockwise and a counterclockwise rotation that touches where they move in the same direction is a particularly unique situation, as there is less frictional force existing between them than if both are either clockwise or counterclockwise rotations. It is possible for rotations to move parallel in the same direction where parts touch, but rotation itself is planar, as a disk is, which is contrary to a three dimensional state of spatial equilibrium. It is thus inevitable that there is more friction existing in the three dimensional reality in which we live. It is possible this frictional variation is conserved in a manner similar to an adiabatic process whereby it maintains total frictional energy of more frictional and less frictional components.

For the unit of momentum to be able to move through the plenum, its form constitutes a temporary change at each place it moves to. A restoring force is thus indicated. In compliance with the laws of nature, the medium

of space somehow allows equal opportunity for momenta in all directions. It is thus unlikely there is a rigid structure where opposite rotations line up as a particular lattice of rotational disks. Different rotational aspects merely explain how variant forces can compete for a dynamic state of equilibrium allowing for the particular amount of change, as consistent with an adiabatic process of conserving entropy. The entities within such a dynamic state are undoubtedly more complex than the simple example of rotating disks. They likely constitute intertwining rings (or toroids), as through otherwise hollow centers, as to result in structures contained in a homogeneous and isotropic medium.

Since the unit of momentum is a temporary change in form from place to place, the complexity of this formation of intertwining rings maintains a restoring force. To speculate on its exact structure is a challenging task that might very well provide additional insight into the nature of reality, but such speculation is not necessary to explain light, matter, gravity and so forth, as these explanations merely assume the equilibrium state of the plenum is in compliance with the laws of nature.

In compliance with the laws of nature, light is conventionally defined as massless, even though it has momentum and energy whenever it interacts with matter. It has been defined as such because it can be in the same place and time with other light, and because of a relativity condition that matter needs to increase to infinite mass in order for it to reach light speed. To the contrary, mass is claimed not to be able to exist in the exact same place and time with other matter. For more complexity, space contains inertia insofar as a gravitational field slows the motion of matter and light in it. It, too, is considered massless, but for the sake of consistency, do not consider matter or mass and inertia as the same thing. Light and space thus contain inertia even though they are massless. It is as though the motion of light carries the inertia of space with it.

Friction reduces relative motion. Because the friction reduces motion equally in opposite directions, momentum is conserved, but conservation of energy is here dependent on conservation of motion. As two disks nullify their relative motion, the force of friction is released elsewhere, as wherever less frictional resistance of uniform direction allows it to occur. Resistance is thus transferred for the continuation of relative motion and momentum. This relative motion and momentum is local in the since an infinite force is needed to alter the state of the total plenum whereas the forward resistance and its transfer is in accordance with a path of least resistance.

Forward momentum is thus explained as possible. The actual process more likely consists of string-like vibrations within cells that are also within cells and so on. Nonetheless, the above analogies can also explain how it is possible transverse properties of wave action can occur, as according to the

opposite spins of the momentum. Waves can also crisscross to reveal local interference effects. However, instead of individual momentums combining for new direction, the overlapping of directions is a dominate force in play. In analogy to the strong winds of nature, the resistance force dominates to allow gravitational fields for the relative directions and speeds of matter and light according to spacetime curvature.

Light, Matter and Energy

The plenum condition of rotation has implications with regard to the polarity of electric charge as well as the simpler non-polarity condition of gravity. Pertinent questions become: How does matter and antimatter differ from the other? How is constant light speed possible? How does light not impede the motion of other light? How is variable speed of matter possible?

Light needs a free path for exchange of forms for it not to impede the motion of other light. The elasticity of the æther thus needs to be such that the superimposing of forms does not change the individual momentum of change in form. Consider disks for an analogy. If the perimeters of all disks move at the same speed, such that each disk does not change position with any other disk, then the transfer of forms from disks to other disks could occur as mutual changes in the size and number of disks that rotate within a larger disk in transferring their effect in a particular direction.

If edges of disks of various diameters move at the same speed, such as for one with twice longer radius to loop over twice as far in twice the time by having half the curvature, then it is possible for exchanges of friction to occur at constant speed. However, shorter loops of shorter radii allow more changes to occur in less space. More frequent transfers at shorter distances thus constitute more frequent actions of change with regard to propagation of frictional energy. If the action is that of light, then all light moves at the same speed and with more energy in direct proportion to its shortness of wavelength. It is further quantized since the parameters mvr of the Planck constant relate as constant speed $v = c$ of a unit of momentum m in inverse proportion to the wavelength r. The quantum aspect of it is also consistent with conservation of momentum in that violation of the law would occur if the action spreads as to decrease the momentum in its original direction.

How does relative motion of mass differ from relative motion of light?

Light does not interfere with other light, whereas matter impedes the motion of light and matter. Matter entails a different process of exchanging form, which is similarly explained as superimposed momenta, but also as an implosion and explosion of frictional forces, as within different equilibrium states of existence instead of a particular equilibrium state of resistance for a constant speed everywhere in it. Relative motion is thus determined as mass emitting and absorbing, or reflecting, light.

First consider the particle effect of an electron as a rotation of æther. Surrounding filaments of æther tend to follow the direction of rotation, but other filaments tend to follow the rotation of other electrons for the kinetic energies of opposing filaments to create a force field of opposing charge.

Consider next the electron is a particular rotation of æther as a particle effect similar to a matter and antimatter composite (as differing in clockwise and counterclockwise rotation). Surrounding filaments align with rotations of the electron-positron pair, but they oppose filaments that align with the rotations of another electron-positron pair, as for a force field for opposing charges to exist. Filaments moving parallel in the same direction and having less friction between them result in non-opposing charge, as in allowing the electron-positron pair to be pushed together until they superimpose where their opposite spin momenta oppose to transform into radiant energy.

There is no superimposing of mass in view of a plenum. The example is only symbolic. More to the point, the change in spin alignment results as the inevitable condition of frictional asymmetry whereby there is a quantum probability of a frictional encounter of opposing spins. Matter-antimatter is a complex development wherefrom unequal amounts of them are according to how we perceive effects of one on the other. However, they are actually separate parts of matter whereby the change in form of three-dimensional space implodes to convert energy as moving in a one-dimensional direction as radiation does. The process is comparable to the electric charge in cloud formation. Energy builds until a free path becomes available for a discharge. However, the path is not totally free. Wind, lightning and thunder occur as frictional resistance.

Since electrons generally repel other electrons, how do electric currents of electrons flowing in the same direction attract?

Effects of electron charge are more complex with regard to its primary nature. Because the plenum is a dynamic state of equilibrium, the haphazard flow of electrons in opposite directions constitutes an activity greater than an inertial-gravitational equilibrium state of matter. Electrons moving in the same direction are less inclined to interfere with each other, which results in less activity for less frictional resistance as a negative inner state of dynamic equilibrium subject to more outside influence.

The implosion of inertial space is similar. It tends towards centers of greater action of change with regard to smaller diameters. Outside inertia of friction combines to push inward towards greater energy density wherefrom change occurs more frequently in its natural manner.

The polarity of electric charge is also explainable. A charge of a proton nullifies a charge of the electron, but a displaced electron displaces another electron in an atom and so on in other atoms to propagate effect here and there, as towards a charge of opposite polarity according to least resistance.

Equivalence

Emitted radiation further provides for a vacuum effect for both gravity and electrical attraction, but it is a manner of how gravitational radiation is emitted that determines the equivalence of gravitational and inertial mass. The energy of radiation emitted by matter is Doppler shifted in maintaining relative motion. The inertial and gravitational equivalence of mass is simply this proportionality of mutual emissions of radiation maintained for relative motion according to the Doppler principle.

The emitted radiation for equivalence is long range, as only gradually detected by matter, as compared to the superimposing of inertial space onto matter. A center of spatial implosion for vacuum effect changes according to the relative distribution of mass. There is no violation of conservation of momentum since the direct action of gravity is from a negative ripple effect of continuous creation and equal annihilation of the gravitational radiation producing vacuum effect according to the Doppler principle. It is also from the superimposing of inertial mass through æther instead of from the direct action of emitted radiation on matter. The gravitational action is thus more complex than a mere change of a particle's momentum of say a graviton at a particular place in time.

Momentum transferred to matter from gravitational radiation is partial and constant in proportion to the spacetime curvature that results from the presence of mass. The total exchange is long range, part elusive and gradual, as according to the probability conditions of quantum physics. The escape from confinement of the gravitational field is thus without detection except for escaped radiation resulting in the gravitational or vacuum effect. Critical to this explanation is a recycling process, as in view of a tired light theory. Emitted radiation is absorbed gradually for the long range effect of gravity as an observational limit within an infinite universe. The gradual process of converting radiation into inertial space is why the force of gravity per mass and time is extremely less than electromagnetic and atomic forces.

Vacuum Effects

After introducing the quantum to explain blackbody radiation, Planck attempted to explain the underlying nature of it in accordance with classical electromagnetism. His explanation further relates to a state of zero point energy (ZPE) that is also referred to as a vacuum field. Development of this ZPE explanation has not become part of established physics, as of yet, but indications are that it could assist in the unification of physics.

The vacuum field of ZPE does not mean space is empty. It is a ground state at equilibrium temperature of absolute zero. Einstein and Stern further hypothesized the condition with regard to the study of hydrogen gas at low

temperatures. The data indicated an oscillatory state of vibrations does exist at absolute zero. Walther Nerst (1864-1961) later proposed the ZPE theory as the vacuum space filled with a latent form of electromagnetic energy.

Plank had reinterpreted his formula as pertaining to the energy of an oscillator that cannot lose any energy that is smaller than hf at absolute zero temperature. Quantum effects thus result. Consider a field of energy similar to balls and springs maintaining equilibrium in various states of vibration. The states, as standing waves of a stable structure underlying the observable world, balance out as undetectable energy for the most part. Heisenberg's uncertainty principle provides theoretical support for the relation. Because there is an uncertainty of both exact position and momentum of an atomic particle, there is a probability anywhere in space a particle exists. Since these probabilities result in accurate predictions, there is a virtual field of particles as a potential source of energy inasmuch as a particle detectable at absolute rest contradicts the non-observance of precise position of zero momentum and precise time of zero energy.

Experimental evidence was provided by Hendrik B. G. Casimir (1909-2000). In 1947, he and Dirk Polder (1919-2001) experimented with metallic plates for the measure of a van der Waals force between the plates and their polarized molecules. An attractive force bringing the plates closer together seemed to occur if they were placed close enough together that radiation of longer wavelengths cannot fit between the plates. The effect is explainable as a medium of energy no longer being in balance to cancel effect; all waves moving in every direction combine in cancelling effect except for a lack of longer, less energetic waves missing between plates for more outside force to act against the inside force.

Niels Bohr had suggested to Casimir that the experiments could relate to ZPE. Casimir complied with Bohr's suggestion by formulating a theory in 1948. Experimental evidence as accurate to within fifteen percent of the predicted value of theory came much later in 1997 by Steve K. Lamoreaux. More accurate results followed. However, Robert Jaffe explained, in 2005, the Casimir force as a relativistic effect of retardation of the van der Waals force between the metal plates. The evidence for ZPE theory was seemingly explained away. However, there are different ways to explain phenomena, depending on what and how they relate. Since ZPE attempts to explain the underlying nature of the quantum, and since the Casimir force is explainable by ZPE, relativity theory and the probability conditions of quantum theory, ZPE seems a promising candidate for the unification of theory.

Another criticism of the ZPE theory is with regard to a lack of longer waves between closer walls for less total energy to counteract outside forces on the walls. Outside forces thus push the walls closer together to obtain an even greater unbalance of energy ad infinitum for no possible separation of

the walls. However, the nature of ZPE is its own remedy to this criticism. As outside forces create a greater density of inner energy, the greater energy density obstructs mean free paths of ZPE from all directions in absorbing it to counterbalance with outside energy. However, the inside added energy is merely absorbed from the plates' inelastic collisions with outside energy, as for another interpretation in compliance with conservation of energy. This effect merely allows the frictional resistance of the plenum to be according to a particular state of matter. Since the state of matter is subject to change, observation of the plenum can change as well.

This explanation is consistent with the quantum probability condition. For instance, Earth only detects a minute portion of the enormous amount of neutrinos passing through it, which is also consistent with the condition that gravitational radiation from matter is only gradually detected by other matter. More consistency is with regard to the Stephen-Boltzmann Law and the nature of the atomic structure.

According to the Stephen-Boltzmann Law, thermal energy of radiation emitted from a blackbody increases in ratio to the fourth power increase in the absolute temperature of the blackbody. Similarly, a fourth power ratio occurs with regard to the nucleus of the hydrogen atom having more mass and shorter radius, both by 1836.15 times, than an electron mass and radius at the outer edge of the atom, such that the nuclear mass-energy density is 1836.15 times greater to the fourth power than is the rest of the atom. For an explanation, consider the surface area per volume of nuclear mass is also 1836.15 times greater than a surface area per volume of the atom. Consider also that the plenum density of substance is everywhere the same, such that the energy of the nucleus is with regard to an equilibrium state of an atom's outer shell. However, the energy density acting between shells can vary. If it were the same, then the total action between shells on the shells occurs 1835.15 times less often, but also 1836.15 times squared greater on an equal amount of the inner shell area. Thus, to compensate for more surface area pressure per volume of mass-energy, the nucleus needs 1836.15 times more mass-energy for containing itself. If smaller, more compact energy is further associated with wave properties of light, as shorter and more vibrant waves, then it is also consistent with Wien's displacement law whereby the radiant wavelength shortens inversely according to an increase in temperature. The result is greater energy density in ratio to the fourth power of the nucleus of a hydrogen atom, as consistent with the thermodynamics of the plenum.

Neutrino-Light Composites

What keeps space from overfilling by constant creation of gravitational radiation? The radiation is a long range and gradually detected process that recycles back to inertial space energy. A neutrino is typical of this process.

Only a tiny fraction of it is detected as it passes through matter, as similar to how light moves through glass and other transparent materials. Moreover, the neutrino appears to have properties distinct from both light and other atomic particles. Originally assumed to have no rest mass, and to move at light speed, it is now believed to have a small mass for it to move nearly at light speed. However, it remains controversial as to whether it is either light or matter.

Pauli proposed in 1930 the neutrino can help explain conservation of angular momentum (spin) along with energy and momentum with regard to a decay of atomic particles. De Broglie had proposed in 1932 that photons of light are composed of neutrinos and antineutrinos, but his proposal came into disfavor with the discovery neutrino oscillation, as changing from one neutrino form into another. Maurice H. L. Pryce (1913-2003) further, as in 1938, put forth a theorem that neutrino waves are longitudinally polarized, lack rotational invariance, and are in contrast to the wave theory of light.

The neutrino still has interesting properties to consider. For instance, an antineutrino-proton interaction results in a production of a neutrino and a positron, the anti-electron, but the positron then reacts with an electron to convert into two gamma rays. Similarly, a neutron in the nucleus of the atom is detectable by a release of a gamma ray. Neutrinos and antineutrinos appear not to have an electromagnetic charge. Ettore Majorana (1906-1938) proposed they are the same particle, as distinguishable according to a non-superposition of the mirror image of two chiral forms. Neutrinos in general associate particularly with the electron, muon and tau. A neutrino is nearly massless. It appears as electrically neutral. It is partially undetectable. Thus it is possible it is continuously emitted by matter to gradually be reabsorbed by matter even as only typical of the gravitational process.

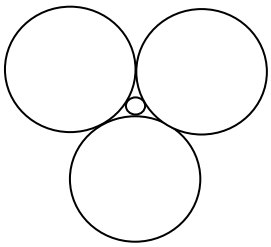
The gravitational effect is explained as a vacuum effect caused by mass emitting electromagnetic waves that gradually convert their energy to inertia of space as a recycling process. The Hubble Constant can be interpreted as consistent with this recycling condition. However, electromagnetic waves of ordinary light are not a continuous process, and the gravity effect requires a constant emission of radiation equal to the same amount of inertial space matter absorbs, as with no other evidence of its occurrence. Although tired light is typical of the process, it is a more general equilibrium condition of electrical attraction and repulsion. To the contrary, radiation of gravity is a particularly unique condition of equilibrium from which the electrodynamic one deviates.

Mass and Volume Ratios

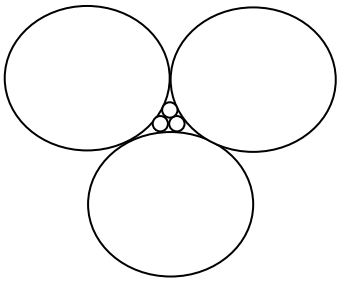
It is proposed that mass derives as an implosion of plenum content of no variable density, and that energy is detected from the changing of form.

Because the proton and electron have the same plenum content per space, the mass-energy of that content is connected with the surrounding space as such whereby volume ratios coincide with mass ratios. Carl R. Littmann and Greg Volk, among others, have investigated the similarity of volume ratios to mass ratios to find a remarkable similarity. Such atomic masses as the proton, kaon, pion and muon are indeed typical of this process.

The kaon (K meson), characterized for strangeness, is about half the mass of the proton, and it decays into two charged pions. Pions (pi mesons) have masses less than a third of the kaon mass, and they decay into muons and muon neutrinos, and less often into electrons and electron neutrinos. The muon is a heavier version of an electron, as not to be comprised of any smaller particles, but it appears unstable.

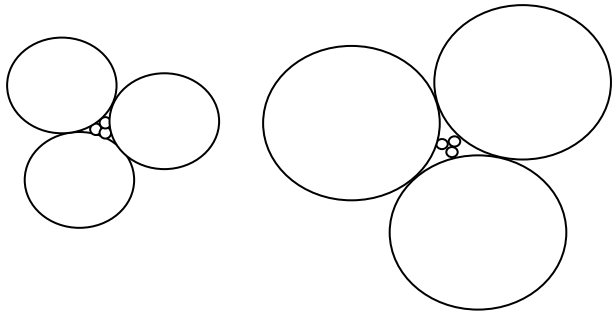


One of Littmann's simplest volume ratios with mass ratios is that with regard to the pion mass in ratio to the electron mass. As depicted above, if three large spheres circumscribe a smaller sphere, as in a plane, the radius of the large sphere is 6.464 times longer than the small sphere radius, and the volume of the large sphere is 270.1 times larger than the small one. A pion mass on the average, as with positive, negative or neutral charge, is 270.13 times the electron mass. The difference in electron mass of a charged pion of greater mass and a neutral pion is about 9 electrons: 273.13 – 264.14.

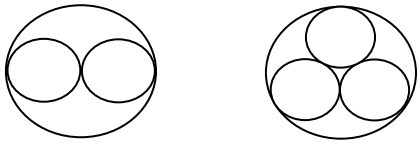


The kaon-electron mass ratio comparison, as illustrated above, is three large spheres circumscribing three small ones, whereby the ratio of the large

sphere radius to the inner small sphere radius is 9.89898 to 1, whereby their volume ratio is 970 to 1. The average between the kaon mass either charged or not charged in ratio to the electron mass is 969.98. The difference in the kaon as either charged or not charged is about 8 electrons: 973.92 – 966.04.



The proton relates as the average of two volumes, one formed of three small spheres packed between crevasses of three large spheres and the other formed of three small spheres with positions opposite the crevasses. As for the small spheres packed between crevasses, the big and small sphere radii ratios relate as the kaon, but if the small spheres are positioned opposite the crevasses, the radii and volume ratios are 13.9282 to 1 and 2702 to 1. The average of 970 + 2702 is 1836, as compared to the mass ratio of 1836.15 to 1 between the proton and electron.



The muon relates to the proton in the manner of the average size of two circles whereby one is one of two same size circles, and the other is one of three same size circles, circumscribed within the same large circle. The large circles compare to that of the proton mass of 1836.15 electron masses. The ratio of radii between 1 of 2 small circles to the large one is ½. The ratio of one of 3 small circles to the large one is 0.4641 to 1. Volume ratios are 1/8 and 0.0999619 to 1, respectively. An average of the volume ratios is a ratio 206.53 to 1836.15. The empirical value of the muon is determined as 206.7682838(24) electron masses.

In view of the volume ratios in relation to the proton, kaon and muon, it is conceivable that a muon of 206.77 electron masses is ejected along with an electron and light energy from 3879.92 total electron masses consisting of 2 non-charged kaons and 2 charged kaons in the formation of a proton

and neutron totaling 3674.83 electron masses. Four kaons minus the muon are 3673.15 electron masses.

The number 9.89898 as the ratio of a kaon radius to an electron radius is significant in that it has been derived separately by Greg Volk and Harold Aspden. Volk also related it in comparing mass ratios to volume ratios, but Aspden derived 8.89898, which is (9.89898 – 1), according to a combination of electrostatic formulas, and he related it according to the creation of the proton from muons.

Greg Volk calculated the number 9.89897 according to the tetrahedral pattern of 4 spheres packed around a center one. The center of the smaller one is the origin of 3 perpendicular axes. The centers of the 4 larger spheres are at coordinate points (1 1 1), (1 –1 –1), (–1 1 –1) and (–1 –1 1). Distance D of the radius R from the origin is

$$D = \sqrt{1^2 + 1^2 + 1^2} = \sqrt{3}$$

The spheres are symmetrical to touch each other along planes of respective axes such that the radius R of a sphere is

$$R = \sqrt{1^2 + 1^2} = \sqrt{2}$$

Radius r of the inner sphere is coordinate distance D minus radius R, such that

$$\frac{r}{R} = \frac{D-R}{R} = \frac{\sqrt{3}-\sqrt{2}}{\sqrt{2}} = \sqrt{\frac{3}{2}} - 1$$

$$\frac{R}{r} = \frac{1}{\sqrt{\frac{3}{2}}-1} = 4.449489743 = \frac{1}{2}(8.898979486)$$

An outer sphere of radius R' = D + R circumscribing the 4 spheres in ratio to r = D – R is

$$\frac{R'}{r} = \frac{D+R}{D-R} = \frac{\sqrt{3}+\sqrt{2}}{\sqrt{3}-\sqrt{2}} = 9.898979486$$

Nearly perfect kaon-electron mass-volume ratio of 3 spheres circumscribing the 3 smaller spheres is thus equal to a large-small sphere ratio of the large sphere circumscribing 4 medium spheres circumscribing the small sphere.

Generally the proton is contained within the nucleus of the atom that has a radius that is about 1836 times shorter than the atom. The actual radii of the electron and proton are theoretical. The plenum itself does not vary

in density, but it is reasonable that particles of higher energy are contained within a smaller space from a larger space, such that the larger space is both the medium of their creation and their containment.

Such speculation on mass-volume ratios might not have any practical value, but tetrahedron and icosahedron patterns have proven to be useful in chemistry and biology. The icosahedron is used in chemistry for describing nanoparticles contained in such crystals as cluster compounds of boron and carbon atoms. In biology, particular viruses protected by protein surfaces contain subunits that also best fit the icosahedron.

Number Ratios

Arthur Stanley Eddington (1882-1944) speculated on the fine structure constant in the mathematical manner

$$1 + 2 + 3 \ldots + (n = 16) = \frac{1}{2}n(n+1) = 136$$

Further speculation is with regard to a 2/3 nature of the electrostatic charge

$$\frac{3}{2}\left(\frac{1}{2}n\right)(n+1) = 204$$

A muon is about 207 electrons, but 9 of the slightly lesser muons are about the same mass as the proton:

$$9\left(\frac{3}{2}\right)\left(\frac{1}{2}\right)(16)(17) = 1836$$

However, the problem with this and mass-volume speculation is the slight differences in theoretical and empirical values lacking explanation.

A proponent of an æther theory who attempted to explain differences in empirical and theoretical values was Harold Aspden (1927-2011). A core of his theory is a proton-electron mass ratio relating to a ubiquitous muon in the manner

$$\frac{m_p}{m_e} = \frac{\left\{9-2\left[\sqrt{\frac{3}{2}}-1\right]^2\right\}E_0}{2m_e c^2} = \left\{9 - 2\left[\sqrt{\frac{3}{2}} - 1\right]^2\right\}\frac{m_\mu}{m_e}$$

$$= (8.8989795)(206.3329) = 1836.1522$$

An empirical value of m_p/m_e as 1836.1527 compares favorably to Aspden's 1836.1522, but his m_μ/m_e value of 206.3329 is slightly off the mark of the

empirical value of 206.7683. However, the muon in the above formula is more of a ghostly muon. Aspen had derived the value of 206.768038 as well as having predicted accurate values of a proton-electron mass ratio, the fine structure constant, and the proton's magnetic moment.

The number 9.898979486 that Littmann and Volk used in relating the radii of the electron and kaon is one electron radius more than a ratio of the proton and muon mass according to Aspden's formula. Aspden had derived it in relation to the ratio of the proton and muon masses in accordance with a combination of two formulas previously derived by Charles-Augustin de Coulomb (1776-1826) and Joseph John Thomson (1856-1940), respectively as

$$\frac{-e^2}{(x+y)^2} = -mv^2 \qquad \frac{2e^2}{3x^2} = mc^2$$

The Coulomb formula is according to an electrostatic interaction between two particles of opposite polarity whose centers are separated at a distance equal to (x + y). Thomson's formula pertains to the internal mass-energy of the mass m of radius x. The Coulomb force is attractive, as negative, and assumed here as containing the internal mass-energy m within the sphere of radius x. The two forces are thus equal in magnitude such that |v| = c and

$$\frac{-e^2}{(x+y)^2} + \frac{2e^2}{3x^2} = 0$$

$$\frac{e^2}{(x+y)^2} = \frac{2e^2}{3x^2}$$

$$\frac{y^2}{x^2} = \left[\sqrt{\frac{3}{2}} - 1\right]^2$$

$$\frac{m_p}{m_e} = \frac{2m_\mu x^2}{y^2} = \frac{2m_\mu}{\left[\sqrt{\frac{3}{2}}-1\right]^2} = 9m_\mu - 2\left[\sqrt{\frac{3}{2}} - 1\right]^2 m_u$$

The significance of this combo formula is that Aspden not only relates the minute lifetime of muon-anti-muon annihilation for the proton's creation; he theorizes it as an annihilation process in relation to interactions between different size gravitons, such that the factor linking the muon to the proton links matter and gravitons. His gravitons are similar in theory to the Higgs boson introduced by Peter Higgs for creation of mass, as the boson absorbs mass-energy of space.

It is noted that Aspden denied the validity of relativity theory, whereas relativity is here explained as a consistent modification of the laws of nature in accordance with effects of relative motion through the æther. The effects are according to the Doppler principle insofar as gravitational and inertial mass equivalence is determined according to how matter emits radiation in opposite directions in conserving momentum. However, the measure of a relativistic effect depends on the condition of symmetry. If the magnitudes of relativistic effects are the same on both sides of the equation, then they cancel each other out.

Aspden's combo formula consists of an outside energy containing the internal mass-energy of matter. Similarly, there is a fourth order effect in view of relativity theory relating to the ratio of gravitational and electrostatic forces:

$$\frac{m_a u^2}{m_a c^2\left(1-\frac{u^2}{c^2}\right)} - \frac{m_a u^2}{m_a c^2} \approx \frac{m_x u^2}{m_a c^2} = \frac{u^4}{c^4} \approx \frac{G m_a^2}{e^2} \approx 8.0 \times 10^{-37}$$

By SRT, kinetic energy is defined as the relativistic increase in mass. Here it is related to the relativistic increase in potential energy of the mass m_a of the hydrogen atom. According to the Schwartzschild Metric, light speed and relative motion are relatively slow in ratio to the relativistic factor squared. The increase in m_a is $m_x \approx m_a u^2/c^2$. It is the potential energy per internal energy of mass m_a.

The equation relates increase in mass-energy according to the relative motion known as a drift velocity. The drift velocity is the average velocity of atomic particles moving in a particular direction due to the presence of an electric field. For an electric current of three amperes moving through a cubic meter of copper wire, the drift velocity is calculated as 0.00028 meters per second. The velocity $u \approx 0.284$ m/sec is about a thousand times greater than the drift velocity through the copper wire. However, the copper wire is about 10^6 times denser than the hydrogen atom. Since u is in proportion to m_a^2, one thousand times less drift velocity is consistent with 10^6 times less mass.

A rational vindication for using the drift velocity is with regard to The Drude Model and Ohm's Law. Paul Drude (1863-1906) proposed in 1900 that colliding electrons move in zigzag paths while drifting in the opposite direction of an electric field E. The drift velocity results as the average initial velocities of the electrons according to the current density J and the electric field E. The average momentum p of the drift is $p = -eE\tau$, where $-e$ is the electrostatic unit of charge, and τ is the average time between collisions. By Ohm's Law, the current density J is the product σE, and σ is a conductivity of electricity. Ohm's Law is sometimes expressed as $I = V/R$, whereby R is

the resistance to the current I of voltage V, as determined by the potential difference through a conductor. In another sense, the resistance relates as a permeability of the electromagnetic medium, as subject to the second law of thermodynamics in requiring any resistance of activity emit heat, as in the form of either radiation or kinetic energy. The resistance relates to plenum cosmology as well in the sense that the perception of reality is according to how change maintains.

Relating Gravity and Electrodynamics

There are numerous electrostatic and magnetic laws of force. Coulomb and Ampere proposed action at distance formulas in analogy to the inverse square law for gravity that had been established by Newton, but Faraday, Maxwell, Weber, Lorentz and others proposed formula to explain electrical action more completely.

With action at a distance are secondary effects similar to perturbation theory of QED that include infinite power series similar to the one Planck used in deriving formula for blackbody radiation. Infinite series also apply to relativity theory, as with regard to the addition of velocities theorem and an addition of gravitational potentials as well. If Observer C, for instance, moves relative to Observer B the same as does Observer B move relative to Observer A relatively at rest, then relativistic effects of Observer C relative to Observer A, such as x in relation to relative mass or the duration of the event, are related to the next power of the relativistic factor in the manner

$$\frac{xv_{12}}{\sqrt{1-\frac{v_{12}^2}{c^2}}} = \frac{x(2v)}{\left[1+\frac{v^2}{c^2}\right]\sqrt{1-\frac{4v^2}{\left[1+\frac{v^2}{c^2}\right]^2 c^2}}} = \frac{x(2v)}{\sqrt{\left[1+\frac{v^2}{c^2}\right]^2-\frac{4v^2}{c^2}}} =$$

$$\frac{x(2v)}{\sqrt{1+\frac{2v^2}{c^2}+\frac{v^4}{c^4}-\frac{4v^2}{c^2}}} = \frac{x(2v)}{\sqrt{1-\frac{2v^2}{c^2}+\frac{v^4}{c^4}}} = \frac{x(2v)}{\sqrt{\left[1-\frac{v^2}{c^2}\right]^2}} = \frac{x(2v)}{1-\frac{v^2}{c^2}}$$

The above result is C relative to B relative to A. For D relative to B instead of relative to C, the result is the same, as in accordance with the principle of covariance. Since x of B is greater by the relativistic factor relative to A, the result is

$$\frac{xv_{13}}{\sqrt{1-\frac{v^2}{c^2}}\sqrt{1-\frac{v_{13}^2}{c^2}}} = \frac{x(2v_{12})}{\sqrt{1-\frac{v^2}{c^2}}\sqrt{1-\frac{v_{12}^2}{c^2}}} = \frac{x(4v)}{\sqrt{1-\frac{v^2}{c^2}}\left[1-\frac{v^2}{c^2}\right]} = \frac{x(4v)}{\left[1-\frac{v^2}{c^2}\right]^{\frac{3}{2}}}$$

The power increase continues with regard to observers E, F, G, etc.

Although the fourth order effect is explainable as a relativistic effect, relativity theory is mainly a modification of other theory for complying with the relativity of space and time. Relativity is thus only a part of other theory. For instance, advancing the fourth order drift velocity effect according to electromagnetism might be more useful for a more complete explanation of reality. Charles Lucas Jr., for instance, formulated a fourth order effect as a combination of a Lorentz Force and Ampere law of induction for a moving charge. Among its many claims is an explanation of Bode's Law.

Andre Koch Torres Assis has also generalized the Weber force law for an electromagnetic force between two neutral dipoles to compare favorably with Newton's law of gravity and the 4th order electromagnetic effect with regard to mass of the order of the hydrogen atom. In this work is a velocity dependent potential energy U that Weber presented in 1848. It is of the form

$$U = \frac{q_1 q_2}{4\pi\varepsilon_0 r}\left[1 - \frac{\dot{r}^2}{2c^2}\right]$$

The r with a dot over it denotes a velocity component, $4\pi\varepsilon_o$ is a constant for permeability, and q_1 and q_2 are two interacting charges. This formula was criticized by Helmholtz with regard to a negative mass component at high potential within the charged spherical shell. T. E. Phipps Jr. overcame this objection with regard to an infinite series expansion of higher power terms. Assis considered the higher order terms of the fourth power with regard to the fourth order effect.

HUBBLE COSMOLOGY

Why an infinite amount of stars does not light up the sky at night is Olbers Paradox. Aristotle proposed a finite number of stars. Kepler considered the night sky indicates a finite universe. A century later, Edmun Halley (1656-1742) argued an uneven distribution of stars could allow for the dark sky of night. In 1743, Jean Phillippe Loys de Cheseaus (1718-1751) considered the universe is finite unless there is something in space that absorbs light. As a response to this consideration, Heinrich Wilhelm Mauthaus Olbers (1768-1840) believed an interstellar dust is an absorbing medium within an infinite universe. The debate persisted in his name.

A main criticism of the interstellar dust theory is the belief that dust in thermal equilibrium absorbs enough light from infinite stars to heat up and reemit the light. However, Eddington and others showed that if the overall temperature of the universe is only about 3° Kelvin, then there can still be a state of thermal equilibrium for some other process than that of just heating of the medium. According to tired light theory, for instance, space partially absorbs light energy. It is further possible that the absorbed energy converts to other forms of energy for the creation of new stars and galaxies as older ones emit enough light to burn out of existence.

Energy converts from one form to another. Matter absorbing light for increasing in relative motion also increases in relative mass. Mass and light both interrelate with gravitational fields. A need for a more comprehensive theory is thus not out of the question. Here proposed is a recycling universe where light emitted from matter is partially absorbed by space to maintain a state of equilibrium in a consistent manner with the Hubble Constant.

The Hubble Constant

In 1917, Einstein proposed a model of the universe as static and finite. For it not to collapse by gravity, he also proposed a counter-repulsive force to gravity that is justified as a mathematical option from the integration of

his field equations of GRT. Integration involves the addition of constants having any value, including zero, since differentiation, which is the reverse of integration, eliminates them. As differentiation eliminates constants, they become unknowns with regard to integration.

The nature of the constant depends on the nature of whatever is being integrated. Because Einstein's equations pertain to spacetime curvature, the cosmological constant obtained by integration refers to a repulsive force as counter to gravity.

Even with the cosmological constant, a more in-depth examination by Alexander Friedmann (1888-1925) determined Einstein's model of a finite universe is unstable unless there was an initial state of expansion. Georges Hanni Lemaitre (1894-1966) responded in proposing the universe is indeed expanding from a singularity, as according to the Schwarzschild solution of Einstein's general field equations.

Astronomers also discovered that starlight emitted from more distant sources appears to be, on the average, more towards the red end of the light spectrum as weaker than a blue light of shorter wavelength. Melvin Slipher (1875-1969) is credited with being the first, from 1912 to 1919, to measure light spectrum of galaxies as having an average increase in its wavelength at a longer cosmic distance. In 1924, Carl Wilhelm Wirtz (1876-1939) assumed the redshift of starlight in relation to the faintness of a galaxy and its farther distance relates to a recessional velocity of the galaxies. The big bang theory soon followed. Carl Powell Hubble (1889-1953), observed a classification of stars, Cepheid variable by name, whereby the data indicated a correlation of redshift with distance, a relation that is now known as the Hubble Constant. His proposal of the Hubble Law in 1929 vindicated its derivation two years earlier by Georges Lemaitre (1894-1966) in advocating the expansion of the universe.

A counter proposal, with less theoretical support, was made by Fritz Zwicky (1898-1974). He offered the possibility a redshift results from light losing its energy while moving through space instead of losing it at the start from the recessional speed of the source. His proposed explanation of the redshift was the gravity of stars. His explanation did not appear plausible to most other physicists, but he might have persuaded Hubble to state that the redshift as a recessional motion of stars had not been determined as fact.

Tired Light

Although Zwicky and other prominent physicists proposed tired light as an explanation of the redshift, their proposals were ignored in favor of a debate between a "big bang" and a "steady state" theory, both of which are according to an expanding universe of finite mass. By big bang theory, the universe is created from a singularity that is now continuing to expand. By

steady state theory, the universe expands to allow for the creation of new stars as the expanding ones burn out of existence. With the discovery of the cosmic microwave background radiation (CMBR) with average temperature of 2.8° K, as predicted by big bang theory, that theory won out as most acceptable. However, even though the big bang theory is now credited with predicting this temperature, Eddington and Regener had predicted it earlier according to an interstellar dust in a state of equilibrium such that the dust did not heat up enough to fill all of the night sky with light.

Neither Eddington nor Regener proposed a tired light theory. A more recent tired light theory, as conditional to quantum physics and an average value of the Hubble Constant, as determined by various astronomers over the years, has been proposed by Lyndon Ashmore. The only difference of it and quantum physics is that it contains a constant k of proportionality that is remarkably equal to exactly one cubic meter, such that

$$H_1 = \frac{hr_e}{m_e k} \approx 64 \frac{km}{(sec)(Mpc)} \tag{1}$$

H_1 is Ashmore's value of the Hubble Constant, m_e is the electron mass, as determined according to experiment, and r_e represents a particular value of the electron radius, as consistent with theory. The constant k as exactly one cubic meter, as according to Ashmore, coincides with the average density of mass in the universe as has been determined by astronomical observation.

That k equals exactly one cubic meter is also consistent with the theory of general relativity inasmuch as the density of the universe in ratio to the nuclear density of a hydrogen atom equals the ratio of the electrostatic and gravitational forces of the electron and proton in the hydrogen atom.

The average density ϱ_u of the universe in relation to H_1, as according to Einstein's formula, is

$$\rho_u = \frac{3H_1^2}{8\pi G} = \frac{3c^2}{8\pi R_u^2 G} \approx \frac{3(2GM_u)}{8\pi R_u^3 G} = \frac{M_u}{\frac{4}{3}\pi R_u^3} \tag{2}$$

Since the dimensional value of the Hubble Constant refers to a velocity per distance, H_1 in the equation converts to light speed c for a critical radius R_u in relation to the gravitational escape velocity squared as $c^2 = 2GM_u/R_u$.

The density of the universe in ratio to the density of an atomic nucleus of the hydrogen atom further approximates to the ratio of the gravitational and electrostatic forces between the proton and electron in the manner

$$\frac{M_u}{\frac{4}{3}\pi R_u^3} \div \frac{m_p}{\frac{4}{3}\pi r_n^3} = \frac{M_u r_n^3}{m_p R_u^3} \cong \frac{G m_p m_e}{e^2} = \frac{G m_p}{r_e c^2} \tag{3}$$

The average density of our finite universe in ratio to the nuclear density of the hydrogen atom is thus approximately the same ratio of gravitational and electrostatic forces as between an electron of mass m_e and a proton of mass m_p.

The electrostatic unit of charge e has historically been associated with emissivity and resistance constants with regard to electrostatic and magnetic fields. These constants are here assumed to be part of the Hubble Constant in relation to a relative density and gravitational influence of the observable universe, but this does not mean the emissivity and resistance constants are not essential to a more complete understanding of theory.

By substituting equalities of equation (1), equation (3) becomes

$$\frac{3H_1^2}{8\pi G} \div \frac{3m_p}{4\pi r_n^3} \cong \frac{Gm_p}{r_e c^2} \tag{4}$$

$$H_1^2 \cong \frac{2G^2 m_p^2}{r_n^3 r_e c^2} \tag{5}$$

Although Ashmore's theory appears consistent with Einstein's theory of relativity, as with regard to relative densities, the tired light aspect of his theory is modeled according to quantum physics. A discovery of periodicity, or quantization as it was interpreted, was announced in 1966, and in 1967, by William G. Tifft. Other astronomers have reported similar finds up until the new millennium. However, their reports have generally been discarded by mainstream physicists, as in explaining the reports away as coincidental to lumpiness of the big bang during its early beginning.

The quantization of the redshift is in relation to its increase occurring within clusters of stars and galaxies. It is explainable as something in space decreasing it permittivity and mean free path.

The Ashmore formula relates to a plasmatic state of matter. Plasma is now believed to be 99% of visible matter. The difference between it and ordinary matter is the electrons in the plasma are less tightly bounded to atoms to allow for more electrical activity and motion between the atoms. Since such subatomic particles as the electron are less bounded in a plasma state, there is a difference of how they absorb and emit photons. Instead of emitting what they absorb, they keep a tiny portion of the photon energy as relative motion gained. According to Ashmore, the excess energy of relative motion is emitted as a cosmic microwave background radiation (CMBR), as from collision due to the relative motion of plasma determined according to the various directions light moves before being absorbed.

The CMBR explanation is reasonable, but if the average Doppler shift is to the red end of the spectrum, the CMBR needs to somehow recycle in order for it not to continually increase without limit. It could, for instance,

provide the material needed to create new stars while old ones burn out of existence in a manner consistent with Steady State Cosmology.

As for a recycling of the CMBR, perhaps matter reabsorbs it in various ways. It could, for instance, be absorbed by virtual particles conditional to the probability condition of quantum mechanics. As some stars evaporate, others form from the plasma and CMBR moving every which way.

The overall process might also simulate as a cause of gravity. If plasma is relatively denser near more mass, then it obstructs the mean free path for a greater freedom and creation of CMBR farther away from matter to push plasma towards matter. However, since plasma is matter, the actual cause of gravity relates according to a more uniform equilibrium state of something besides the plasmatic matter. It could, for instance, relate to the dark matter of dark energy as potential energy of a virtual field as conditional to relative motion and the magnitude of a gravitational field.

The Cosmic Coincidence

Suppose a value of the Hubble Constant is 70 km/sec/Mpc. Dividing 70 km/sec by a million parsecs (30.9 million kilometer) equals 2.27×10^{-18} of something per time. If the something is one kilometer, then the result is a kilometer per second. If c is an upper limit for a Hubble distance R of the universe, then $R = c/H_0 \approx 1.32 \times 10^{26}$ kilometers. Dividing R by c obtains a time of about 4.4×10^{17} sec $\approx 7.3 \times 10^{15}$ min $\approx 1.2 \times 10^{14}$ hr $\approx 5 \times 10^{12}$ days $\approx 1.4 \times 10^{10}$ as 14 billion years. If an expansion of the universe to R from a singularity occurred at light speed, then the age of the universe is at least 14 billion years old. Furthermore, if it takes light 14 billion years for it to reach Earth, then the universe is 28 billion years old. However, the radius of the universe could be less than R. If it only half R, as having expanded at half c, it would be 14 billion years old plus 7 more billion years as the time for light to reach Earth. However, ten billion years ago the universe would have been vastly different in gravitational density than what it is now. Stars forming would be conditional to spacetime expansion, but a greater density of stars separating at the same speed at which they now separate results in a different value of the Hubble Constant. It is possible a past expansion was slowed by gravity. As expansion still continues with less gravitational force to slow it, it is now relatively greater than otherwise.

Because distances between stars and galaxies increase according to an expanding universe, and because the Hubble Constant is the change in light spectrum per distance, the Hubble Constant is only constant for distances of a particular time, as to decrease in magnitude in proportion to the longer distance of their separation. Fourteen billion years from now, for instance, the value of the Hubble Constant should decrease to about half of what it is now. Dirac addressed this issue.

Dirac, in accepting a finite, expanding universe as causing the Hubble Constant, speculated on how it relates to the atomic structure. For instance, Hubble Constant H_0, light speed c, electron mass m_e, electronic charge unit e, gravitational constant G, and fine structure constant ($\delta \approx 1/137$) relate in the manner

$$\frac{3e^4 H_0}{2Gc^3\alpha} \approx m_e^3 \tag{6}$$

$$H_0 \approx \frac{2Gm_e^3c^3}{3e^4\delta} = \frac{2Gm_e^3c^3}{3m_e^2c^4r_e^2\delta} = \frac{2Gm_e}{3r_e^2c\delta}$$

$$\approx 2.3 \times 10^{-18}\ sec^{-1} \approx \frac{72\ km}{(sec)(Mpc)} \tag{7}$$

The gravitational force of the electron per light speed thus approximates to the Hubble Constant. However, since H_0 decreases as the universe expands, another one of these constants needs to vary in order for them to maintain mathematical equality. Dirac chose G to decrease along with H_0.

At the time of this speculation, the value of H_0 was only approximately determined for the recessional velocity of a galaxy within an error ranging up to 100 kilometers per second. Even though the degree of error became reduced to a range of less than 2 kilometers per second, various values of H_0 have still been determined by various astronomical observations. More recently, a value considered more accurate is according to data collected by a Wilkinson Microwave Anisotropy Probe (WMAP) that was launched to map fluctuations in temperature of the CMBR. Along with this data a value of the Hubble Constant was initially calculated as 70.5 ± 1.3 kilometers per second per one million parsecs. It became by later calculation 69.32 ± 0.80 kilometers per second per one million parsecs. Still, from the Plank Mission is a more recent determination of 67.80 ± 0.77 km/sec/Mpc.

The calculations, however, are according to theory as well as the data. The theoretical connection is with regard to a big bang theory interpretation of a singularity of GRT whereby the Hubble Constant corresponds in value with the critical radius for a finite universe similar to a black hole. Somehow the black hole universe expands, as allowed by the probability condition of QED, as proposed by Hawking in allowing the black hole to evaporate by it emitting Hawking Radiation.

These values of the Hubble Constant are assumed here to apply with regard to GRT and the relative size of an observable part of the universe, as finite, but also with regard to a different interpretation of the singularity. An exact value of the Hubble Constant, say H_2, is assumed as 70.75 kilometers

per second per million parsecs, or 2.28 x 10^{-18} times per second in dividing by one million parsecs, which equals 3.09 x 10^{19} kilometers.

This theoretical and empirical value of H_2 in relation to the electron mass is not exactly the same as the one proposed by Dirac, but there is still a cosmic coincidence to reckon with in relation to the mass and size of the hydrogen atom, as within the determined accuracy of values given below of the common parameters used in physics:

Values of Physical Parameters

Gravitational Constant: $G = 6.67428(67) \times 10^{-8}$ $cm^3/(gm)(sec)^2$
Proton mass: $m_p = 1.67262137(13) \times 10^{-24}$ gm
Electron mass: $m_e = 9.10938215(45) \times 10^{-28}$ gm
Light speed c: $2.99792458 \times 10^{10}$ cm/sec
Electron radius: $r_e = 2.8179402894 \times 10^{-13}$ cm
Neutron radius: $r_n = 2.881991 \times 10^{-12}$ cm
Fine Structure Constant: $\delta = 1/137.036 = e^2/\hbar c = v/c$
Planck Constant: $2\pi\hbar = h = 6.626069$ $(gm)(cm)^2/sec$
Electronic unit of charge e squared: $e^2 = 23.07 \times 10^{-20}$ $(gm)(cm)/(sec)^2$

The above values are partly a simplification of theory rather than fact. The real value of the electron radius, for instance, could be two thirds r_e in accordance with the Thomson formula of $2e^2/3r_{e'} = m_e c^2$ instead of $e^2/r_e = m_e c^2$. The simplified formula merely relates more directly to the Bohr radius $r_a = r_e/\delta^2$ of the hydrogen atom, such that $r_a(m_e/m_p) = r_n$ and so on.

The Gravitational Coincidence

Dirac proposed a varying gravitational constant to explain The Cosmic Coincidence. Zwicky proposed the redshift in the more distant starlight is related to gravity. It is also considered here as related to gravity, as radiation absorbed by the medium of space that, in return, produces the gravitational effect as dark energy not pushing space apart but pushing it towards matter. Matter reacts by pushing against inertial space. However, the kinetic energy of the action and reaction from all directions superimposes at the center of mass where it emits its increased internal energy as radiant energy creating a vacuum effect in its wake as the gravitational effect.

As with regard to Dirac's proposal, it is here proposed that a decrease in the gravitational constant is nullified by an exact proportional decrease in all other cosmic parameters, such as the electrostatic unit of charge and so on, such that they all are relatively nullified.

There is also a recycling process. The emitted radiation is a long range and partly elusive process determined according to the probability condition of quantum physics, as typical of Earth's detection of only a minute portion of the neutrinos that pass through Earth. Part of the radiation thus escapes

detection except for its gravitational-vacuum effect. As radiation is gradually detected, it converts into space inertia. Space inertia, in turn, superimposes on inertial mass for the continuance of the recycling process.

As for the WMAP determination of H_2, it is a measure of the variation in the temperature of the background radiation according to theory, the big bang, which includes the singularity of general relativity and a critical radius for the size of a finite, expanding universe. The results of the WMAP study are here interpreted differently, as with regard to an observable portion of a static, infinite universe, as similar to Ashmore's theory, whereby both GRT and a quantum probability of expansion apply only to a particular radiation as a gravitational escape velocity of the observable universe.

Consider a critical radius of an observable universe as $R_u = c/H_2$. As c is the upper limit for its escape velocity, a distance r for v is such that v is of the same proportion to c that r is to R_u. Coincidentally, again, a velocity and distance per light speed in relation to the hydrogen atom is the same as its ratio of gravitational to electromagnetic forces, or potentials. However, how it relates to the structure of mass has different interpretation. Since a proton has about 1836.15 times the mass of an electron, since the hydrogen atom is one proton and one electron, and since the proton is within the nucleus of the atom having a radius of about 1836.15 times shorter than the radius of the atom, as the approximate distance of the electron from the nucleus, the calculation approximates the same for relating a Hubble Constant either to a nuclear mass and its radius or to the atom and its radius.

The simpler relation is with regard to the latter:

$$\frac{H_2(2r_a)}{c} \cong \frac{Gm_a^2}{e^2} \cong 8.08 \times 10^{-37} \tag{8}$$

By dividing each side of the equation by r_a, and multiplying them by e^2, they become

$$\frac{2e^2}{c} \cong \frac{Gm_a^2}{r_a} \tag{9}$$

By substituting R_u for c/H_2, equation (9) becomes

$$\frac{2e^2}{R_u} \cong \frac{Gm_a^2}{r_a} \tag{10}$$

By substituting parameters $m_a v^2 r_a$ of e^2 for e^2, equation (10) becomes

$$\frac{2m_a v^2 r_a}{R_u} \cong \frac{Gm_a^2}{r_a} \tag{11}$$

By dividing both sides of equation (11) by r_a, it becomes

$$\frac{2m_a v^2}{R_u} \cong \frac{Gm_a^2}{r_a^2} \tag{12}$$

The centripetal force of two hydrogen atoms at opposite ends of the center of the observable universe thus equates with the gravitational force between two atoms separated a distance equal to the radius of the atom.

The similar relation with regard to the proton mass m_p of the nuclear radius r_n of the hydrogen atom is less simple, but it relates more directly to equation (5):

$$\frac{H_3(2r_n)}{c} \cong \frac{Gm_p m_e}{e^2} = \frac{Gm_p}{r_e c^2} \tag{13}$$

$$H_3 \cong \frac{Gm_p}{2r_e r_n c} \tag{14}$$

$$H_3^2 \cong \frac{G^2 m_p^2}{4r_e^2 r_n^2 c^2} \tag{15}$$

$$\frac{H_1^2}{H_3^2} = \frac{2G^2 m_p^2}{r_n^3 r_e c^2} \div \frac{G^2 m_p^2}{4r_e^2 r_n^2 c^2} = \frac{8r_e}{r_n} \tag{16}$$

The respective radii relate to internal and potential energies as

$$r_e = \frac{e^2}{m_e c^2} \tag{17}$$

$$r_n = \frac{e^2}{m_p v^2} \tag{18}$$

Hence

$$\frac{8r_e}{r_n} = \frac{8e^2}{m_e c^2} \div \frac{e^2}{m_p v^2} = \frac{8m_p v^2}{m_e c^2} \tag{19}$$

The ratio of the Hubble Constant values squared thus equate as 8 potential energies per internal energy of the electron.

The factor 8 could relate to the ratio of escape velocity to orbital speed of free fall and to a slower light speed in the gravitational field. The escape velocity is greater than the orbital speed by the square root of 2, and by the Schwartzschild Metric light speed at a maximum Schwartzschild radius is c'

= (½)c. If c' is the actual escape velocity of the field and c" is its orbital speed, then (c")^2 is 8 times less than c^2 such that

$$\frac{8v^2}{c^2} = \frac{8v^2}{4c'^2} = \frac{2v^2}{c'^2} = \frac{2v^2}{\left[(\sqrt{2})c''\right]^2} = \frac{v^2}{c''^2} \tag{20}$$

Equation (20) is significant with regard to a homogeneous condition of free whereby the relativity of relative motion becomes applicable.

The fraction v^2/c"^{2} is also indicative of a relativistic effect according to the approximation

$$\frac{v^2}{c''^2} \approx \frac{1}{1-\frac{v^2}{c''^2}} \tag{21}$$

The speed v also relates to theoretical orbital speeds of the electron around the atom and the proton around the nucleus of the atom, and v/c = e^2/($\hbar$c) = δ.

As with regard to the ratio of densities,

$$\frac{3H_3^2}{8\pi G} \div \frac{m_p}{4\pi r_n^3} \cong \frac{Gm_p m_e}{e^2} \cdot \frac{m_e c^2}{8m_p v^2} = \frac{Gm_e^2 c^2}{8e^2 v^2} = \frac{Gm_e}{8r_e v^2} = \frac{Gm_e}{r_e v''^2} \tag{22}$$

The density of the observable universe in ratio to the nuclear density of the hydrogen atom thus approximates to the ratio of the electron's gravitational potential to its orbital speed squared around the nucleus of the atom.

A Non Coincidence

In contrast to equations (8) through (12) is a variable Hubble Constant allowed according to the following equations whereby light speed squared equals an escape velocity squared of any mass M of radius R as well as to an electrostatic unit of charge squared per electron mass and electron radius:

$$\frac{2GM}{R} \cong \frac{e^2}{m_e r_e} = c^2 \tag{23}$$

$$\frac{GM}{e^2} \cong \frac{R}{2r_e m_e} = \frac{c}{2r_e m_e H} \tag{24}$$

$$\frac{H(2r_e)}{c} \cong \frac{e^2}{GMm_e} \tag{25}$$

Dividing equation (8) by equation (25), with M now specified as M_u, obtains

$$\frac{H(2r_a)}{c} \div \frac{H(2r_e)}{c} \cong \frac{Gm_a^2}{e^e} \div \frac{e^2}{GM_u m_e} \tag{26}$$

$$\frac{r_a}{r_e} \cong \frac{G^2 M_u m_a^2 m_e}{e^4} = \frac{G^2 M_u m_a^2}{m_e c^4 r_e^2} \tag{27}$$

$$M_u \cong \frac{m_e c^4 r_e r_a}{G^2 m_a^2} = 8.7144 \times 10^{55}\ grams \tag{28}$$

This result indicates the observable portion of the universe is conditional to fundamental parameters. Since the Hubble Constant H factors out, its value is independent of the result. The total mass and size of the universe is thus fixed with regard to its observation.

To the contrary, mass densities of black holes are assumed as variable along with size. However, the black hole was redefined by Hawking for it to emit Hawking radiation and be able to evaporate out of existence. Similarly, in a previous chapter of this book titled General Relativity Analogies, with regard to analogies of relativistic effects of GRT and SRT, the singularity of the Schwartzschild Metric was reinterpreted such that a zero mass density is obtained as a Schwartzschild upper limit.

Also indicative of this process is a Mach principle assuming the inertia of mass and mass gravity is dependent on a relative distribution of mass in the universe. A relative distribution of mass is also conditional to spacetime curvature and the inhomogeneous nature of gravity as force of acceleration, which Einstein had used to explain a gravitational shift in light spectrum as analogical to a shift resulting from a constant change in speed. A relativistic decrease in the mass-energy of the field is thus consistent with conservation of energy whereby energy is spent as gravitational-work-energy.

There can also be an equilibrium state whereby mass receives the same work energy of other mass that itself spends as an adiabatic process.

Unity

The principle of equivalence equates relative motion with gravity. SRT unified classical mechanics and electrodynamics. Why has not the pursuit of a unified field theory regarding GRT and QED been successful?

One possible answer is with regard to the principle of renormalization and the present day interpretation of the Schwartzschild singularity. QED is able to overcome infinities by means of renormalization as a change in scale factor. An increase in energy of the electron, for instance, can result in two particles, such as an electron-positron composite that can further transform into pure light energy instead of infinite mass-energy. However, with regard to this interpretation of the Schwartzschild singularity there is no minimum distance for renormalization to apply.

Is renormalization or the singularity incorrect?

Only the interpretation of the singularity is here proposed as at fault. It only needs to be redefined in a similar manner the black hole was redefined by Stephen Hawking insofar as it is now recognized as capable of emitting Hawking Radiation and even to evaporate out of existence. The redefinition is also to nullify infinities of the observable world.

Infinities of Wave Mechanics are evident of de Broglie wave velocities $V = mc^2/mv_x$ that become infinite as v_x approaches 0. However, if speeds are faster than c, they are only theoretical effects of the virtual field. As with regard to the observable world, the mass-energy mc^2 per relativistic factor α also increases to infinity as v_x approaches c, but such mass-energy is able to convert into the virtual particles. SRT is thus applied in a manner consistent with renormalization of QED. Increasing mass-energy by means of entering into a gravitational field should renormalize as well according to a unique interpretation of the principle of equivalence.

In the chapter General Relativity Analogies, the Schwarzschild Metric was analyzed in determining relativistic spacetime effects of a gravitational field are analogous to those of relative motion. For instance, the relativistic contraction of mass-energy in the gravitational field results in the relativistic spacetime expansion of the field as in analogy to the relativistic increase in spacetime coordinates in the direction of relative motion. Since SRT merely modifies the fundamental laws of nature for their compliance with relative spacetime instead of with absolute space and absolute time, and since GRT is analogous with SRT, GRT is merely a modification of the laws of nature as well. For instance, a virtual field of QED can also represent the primary field whereby relative motion and gravity both determine probabilities as to how they are perceived.

Explaining how relative spacetime expands in the gravitational field is a key part of the reinterpretation. It is explained in a manner consistent with contraction of length according to SRT, an inhomogeneous nature of the gravitational field according to GRT, conditions of probability according to QED, and conditions of a multiverse.

In SRT, the contraction of length in the direction of relative motion allows light speed to be perceived as a constant. The spacetime coordinates of an observer in relative motion also become extended since the clock in relative motion is slow. Within a gravitational field, natural clocks are also relatively slow. They are slow because relative motion, which includes light speed, is slow by the relativistic factor squared, but if the orbital distances between masses and the masses contract by a relativistic factor not squared, then contractions nullify each other for no contraction to be perceived by local observers who are likewise contracted, but any part of spacetime that does not contract is relatively expanded.

How is it feasible that some parts of a field contract while other parts remain the same?

The explanation is according to the inhomogeneous nature of gravity. Homogeneity in this sense means that gravity is the same throughout space. Einstein explained there is no internal awareness of free fall, in view of the principle of equivalence, if everything else in free fall is affected in the same way. However, not everything in free fall is affected in the same way. Tidal effects result because of the inhomogeneous nature of gravity. Ocean tides, for instance, occur because of the greater attraction between the moon and the closer part of Earth to the moon. Still, however, as all things, including light, fall at the same rate, in vacuum space, towards Earth's surface, gravity is still the result of matter and energy following spacetime curvature due to the presence of mass. However, it is also according to the inhomogeneity of the field. Earth's gravity, for instance, cancels itself at its center where it is the same in all directions in cancelling out to zero gravity. The conditions of spacetime curvature are likewise such that a distribution of mass determines both the inhomogeneity and the curvature of the field. Since inhomogeneity both decreases and increases by the presence of mass, not all of spacetime is perceived as contracted; it is perceived as relatively expanded instead.

According to a Perfect Cosmological Principle the universe, on a large enough scale, is everywhere the same for all observers. It is estimated from astronomical observation that the scale for homogeneity is 250 million light years, which is about 55.2 times smaller than our universe at present.

Consider mass m as part of the total mass M of the universe. In accord with the Perfect Cosmological Principle mass m is relatively at the center of the universe whereby there is a cosmic redshift of more distant starlight, but a redshift in the spectrum of light from the surface of m occurs because of gravitational inhomogeneity. However, consider m approaches a mass (M – m) such that

$$\frac{GM}{r} = c'^2 = \left(\frac{1}{2}c\right)^2 = \frac{1}{4}c^2$$

The escape velocity of the field becomes

$$\frac{c'\sqrt{2}}{\sqrt{1-\frac{2GM}{rc^2}}} = \frac{c'\sqrt{2}}{\sqrt{1-\frac{2c'^2}{c^2}}} = \frac{c'\sqrt{2}}{\sqrt{1-\frac{1}{2}}} = \frac{c'\sqrt{2}}{\sqrt{\frac{1}{2}}} = 2c' = c$$

Whereas c is the escape velocity of the field, c' is the orbital speed, which is determined as c by a local observer. It is particular special in relation to the principle of equivalence in that it is a condition whereby light and mass take the same orbital path. Since the path is locally perceived as straight, another

interpretation is that it represents a perfectly homogeneous condition of the gravitational field, as equivalent to gravitational free space, or as the center of a particular observable part of a multiverse. All that is left to determine is whether any black hole condition applies for any M and m or if all universes of a multiverse are the same for any black hole condition.

A universal scale for time and mass-energy is indicated in the chapter General Relativity Analogies with regard to a radial contraction of length in analogy to the contraction of length in the direction of relative motion. This radial contraction is here related to the required nullification factor. If it is assumed to be according to the relativistic factor squared, for instance, then it nullifies slower light speed and relative motion in the field, which are also according to the relativistic factor squared. In effect, time is universal along with conservation of mass-energy. However, the radial contraction within a field is only by a relativistic factor instead of by a relativistic factor squared.

The radial contraction by only the relativistic factor is according to the inhomogeneous nature of gravity, whereas the equivalence principle applies with regard to homogeneity. Assume a relativistic factor squared condition relates to a combo effect of gravity and relative motion. The gravitational effect dominates until the effect of an orbital speed of free fall surpasses it. Further assume homogeneity is conditional to an orbital speed equal to c in relation to a center of mass relatively according to the Perfect Cosmological Principle wherefrom radial contraction is according to the relativistic factor squared.

There are thus two opposite conditions to consider. By inhomogeneity light spectrum is redshifted from the center of mass; by homogeneity there are the gravitational analogies with regard to relative motion wherefore the Perfect Cosmological Principle applies whereby the observer is relatively at the center of the universe. By means of the latter, by means of virtual field for both changing and conserving mass-energy, and by an interpretation of the Hubble Constant according to tire light theory, the redshift of the light spectrum is from sources farther away from the center of mass.

No internal awareness of change occurs of mass if falling freely in a relatively homogeneous gravitational field, but, there is still internal change to consider with regard to an inhomogeneous field of gravity. If all matter inside the Schwartzschild limit relatively contracts, there is further closing of the gravitational field to a shorter Schwartzschild radius, but there is also an expansion of it as relatively perceived by the local observer in the field. Contraction and expansion nullify each other to maintain a particular form of the multiverse according to each local viewpoint of the field. However, it transforms as a different multiverse from emitting mass-energy and gaining it anew from the virtual field of dark energy.

The increase in virtual energy is explainable as the probability of its detection along with the increase in spacetime. However, since increases of spacetime and mass-energy are offset by relativistic contraction–and by the emission of mass-energy as well–the relative size of each observational part of the multiverse maintains the same probability of detecting a particular particle within it. However, the observation is also conditional to how and where the observable universe is perceived. If observed in slightly different locations, then each perception corresponds to slightly different contents of the universe as well.

A unified field theory thus becomes evident with the interrelating of GRT and QED in a manner that all mass-energy is conserved even in view of an observer's change state due to either relative motion or a gravitational field. Moreover, since conditions of probability apply, there is a chance that any portion of a multiverse could actually be expanding, whereby relatively small expansions of less energy occur more often. Similarly, more powerful meteorites from space, hurricanes, volcanoes, tornadoes and so forth are more hazardous to our survival, but they are more infrequent. A powerful enough explosion, for instance, as by a rare matter-antimatter convergence of tremendous energy capable of expanding our observable portion of the multiverse, as from a singularity, still remains a slight possibility. It is bound to relatively occur once in about every fourteen billion years, but the results of how it continues to occur is what redefines the nature of the singularity. As the black hole was redefined by Hawking for it to evaporate according to Hawking radiation, the singularity is similarly redefined for the Hubble Constant to apply according to what method and position in spacetime it is measured by.