THE RELATIVITY OF MASS-ENERGY AND MOMENTUM

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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