General Relativity
And
The Cosmic Coincidence

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After Einstein inserted a cosmological constant into his field equations for a repulsive force that would prevent a finite universe from collapsing by gravity, Alexander Friedmann concluded an infinite number of models were possible. A model here proposed is a finite visible universe within an infinite universe that is in compliance with the theories of special relativity (SRT) and general relativity (GRT). This finite visible portion of the universe is not expanding in compliance with big bang theory (BBT). It is only relatively expanded such that the Hubble Constant is explainable in the manner of tired light theory. However, space-time of a black hole as another universe within a universe is also relatively expanded. Complicating this model is the Cosmic Coincidence, as the value of the Hubble Constant then varies from one condition to another to differ with the principle of equivalence of GRT.

The Cosmic Coincidence had previously been noted by Paul Dirac in using the Hubble Constant to construct such atomic particles as electrons and muons. The accuracy of the Hubble Constant at the time was determined only within the range of about 100 kilometers per second. It has now been calculated from data collected in outer space by the WMAP satellite as $H = 70.5 \pm 1.3$ km/sec/Mpc. As for the Cosmic Coincidence, the Hubble Constant multiplied by the diameter of the hydrogen atom and divided by light speed equals the ratio of gravitational and electrostatic forces between two hydrogen masses (as will be mathematically shown).

Dirac had accepted the cause of the Hubble Constant as recession between the observer and light source, as indicative of an expanding universe. Since in an expanding universe distances between galaxies increase, and because the Hubble Constant is a change in light spectrum per distance, the Hubble Constant is only constant for distances of a particular time. It decreases thereafter. However, the other parameters of the Cosmic Coincidence are constants as well. This meant for Dirac that not all of them could be truly constant, as indications are that at least one of them needs to vary with the Hubble Constant. He chose the gravitational constant as decreasing in time along with the expansion of the universe. Further consequence would be GRT is also in need of modification.

The Cosmic Coincidence appears to be contrary to both BBT and GRT. It is contrary to BBT because it is too extraordinary that the value of H is what it is at this particular time. It appears contrary to GRT with regard to the interpretation of black holes as observable universes within observable universes. With R as the radius of an observable universe or black hole, and with the limiting length of R determined by HR = c, and with R depending on the relative size of a black hole or observable universe, then either H or c varies with R. Although light speed, as in according to GRT, does vary in gravitational field, this aspect of variance is not local. It is thus contrary to GRT (except for one more step in the process).

Of particular question is a founding principle of GRT, the equivalence of inertial mass and gravitational mass. By it the properties of mass are determined to be numerically the same whether measured according to collision or according to weight. Newton was reluctant to assert that they are the same everywhere in the universe. Some philosophers even doubted the local validity of the principle. Ernst Mach, for instance, founded the principle that the inertia of mass depends on the relative distribution of mass at large. The local validity of the principle of equivalence has so far been determined within an accuracy of at least one part in 10^{13}. However, this is not to say mass is determined the same everywhere in the universe. If it differs, then what observers in one galaxy might determine as the same inertial mass as gravitational mass might not be the same as what observers in another galaxy might determine them to be.

Newton assumed absolute space and absolute time as intrinsic properties of nature for the formulation of laws of motion and a theory of gravity. Einstein confronted this assumption with the theory of relativity whereby space and time are considered relative instead. He then postulated the principle of equivalence as the foundation of GRT. This assumption, in turn, is challenged in view of the Cosmic Coincidence, but it withstands the challenge by way of modification.

For the most part Einstein only modified Newtonian Mechanics by way of describing phenomena according to relative space-time instead of absolute space and absolute time. Such laws as conservation of momentum and conservation of energy are maintained. They are likewise maintained for this proposed model of the universe. How they are maintained by GRT is, however, somewhat odd with how they are maintained by SRT and quantum physics.

According to SRT total momentum and total mass-energy are conserved of collisions between masses and between collisions between mass and light. This conservation is of collision in view of any observer in an inertial state of motion. It does not include other mass in view of the observer’s changed state of inertial motion. By Newtonian Mechanics and SRT total momentum of all other mass is shifted in the opposite direction of the observer’s acceleration. Furthermore, total mass-energy according to SRT increases decreases or stays the same depending on how relative motion of the observer changes. Mass-energy is thus conserved with regard to its own interaction, but it is not conserved in view of an observer’s changed state of relative motion.

Conservation of mass-energy and momentum similarly apply to GRT, but how they are conserved is more complicated in view of Einstein's interpretation of the principle of equivalence. By it observers in free fall feel no internal effect of their acceleration insofar as all mass-energy of observation gravitates in the same direction at the same rate.

In contradistinction to non awareness of free fall are tidal effects. Earth, for instance, is in free fall towards its moon. Ocean tides occur because parts of Earth closer to the moon gravitate more towards it. Gravity is thus inhomogeneous by nature. Aspects of its non awareness are nonetheless interpreted as curved space due to the presence of mass. Instead of accelerating by the force of gravity, mass-energy simply follows the path of space-time curvature. Moreover, with no force of gravity to reckon with, conservation laws appear to be inconsequential as well. However, the issue is more entailed.

Besides tidal effects observers standing on Earth's surface resist free fall. Do conservation laws with regard to gravity apply to this resisting force instead of free fall itself? It is here assumed conservation of momentum and conservation of energy apply regardless of the nature of the action, but their empirical validity is conditional to the probability nature of quantum physics.

Space-time curvature somehow results from the presence of mass. Insofar as there is no explanation given as to how a stress condition of space results from the presence of mass it could refer to an unobservable phenomenon not subject to scientific scrutiny, as with regard to causality, and as in being consistent with the probability conditions of quantum physics resulting in vacuum effects. For black holes to be in compliance with the laws of thermodynamics, for instance, Stephen Hawking proposed that a particle existing inside a black hole has a probability of existing outside it. Black holes are thus only black with regard to their cause and effect determination.

To elaborate according to the contiguous process of action as described by SRT, perhaps particles escapes the black hole by converting to a less detectable form of energy, thus creating a vacuum effect in their wake.

Gravity is likely a vacuum effect that results in the warping of space-time, but this vacuum effect must also have a cause. Even if it is not directly observable it is still to be explained here in view of the conservation laws of momentum and mass-energy.

An overview of Newtonian Mechanics, the Mach principle, SRT, and the equivalence principle is therefore undertaken with regard to how conservation of momentum and conservation of mass-energy are maintained. The derivation of relative mass in accordance with these laws is first reviewed and further verified by example with regard to interaction of matter with light. The Schwartzschild Metric is next shown to indicate space contains inertia apart from matter. Gravity is then explained in manner consistent with both the Mach principle and general covariance of GRT. However, the Cosmic Coincidence contradicts this relativistic interpretation of the Mach principle.

Conserving Relative Mass-Energy

According to SRT 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, as according to the equation

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

Also according to SRT mass-energy is conserved after a collision between two or more masses. If the collision is inelastic, and if the total mass is observed from the same reference frame of motion, then the total mass-energy is unchanged.

The total mass-energy is also conserved for an elastic collision, but if there is a change in relative speed of the masses, then there is an exchange of relative mass between masses.

Note: Other mass-energy of the universe changing in view of an observer's changed state of relative motion (acceleration) is not conserved, as conservation of mass-energy does not apply to the observation of a change that is caused by an observer's acceleration that is independent of the action.

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

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

$$m + m_0 = M \tag{2}$$

$$mv_1 + m_0(0) = mv_1 = Mv_2 \tag{3}$$

Equation (2) simply shows the total mass of two separate masses m and m_0 relative to observer A before the inelastic collision are the same as the total mass M relative to observer A after the collision.

Equation (3) is somewhat more complex inasmuch as $m_0(0)$ is at rest with observer A before the collision. Total momentum relative to observer A before 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.

The next step is substituting m and m_0 in equation (2) for M in equation (3) to obtain:

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

$$mv_1 = mv_2 + m_0v_2$$

$$mv_1 - mv_2 = m_0v_2$$

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

$$m = \frac{m_0v_2}{v_1 - v_2} \qquad (4)$$

The objective now is to show:

$$m = \frac{m_0}{v_1 - v_2} = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} \qquad (5)$$

The objective is achieved by converting v_2 in terms of v_1 in order to show the resulting form of the middle part of equation (5) is the same as that on the far right side. In so doing the principle of covariance and the addition of velocities theorem apply. The addition of velocities theorem, as for velocities in either the same or opposite direction, is of the form

$$v_{ab} = \frac{v_a + v_b}{1 + \beta_a\beta_b} \qquad (6)$$

In equation (6), $\beta_a = v_a/c$ and $\beta_b = v_b/c$. The velocity v_a is that of a second observer as measured by a first observer, v_b is another velocity of something else as measured by the second observer, and v_{ab} is the other velocity as measured by the first observer.

In view of an inelastic collision let observer B represent the first observer observing observer A as moving at velocity v_1. Let observer A then be the second observer observing the result of the inelastic collision as moving at velocity $-v_2$. Since the principle of covariance requires the masses are the same relative to each other's point of view, as for comparing corresponding values with equation (6), the velocity $-v_2$ as perceived by observer A is v_2 as perceived by observer B. By substitution, equation (6) becomes

$$v_2 = \frac{v_1 - v_2}{1 - \beta_1\beta_2} \qquad (7)$$

$$v_2(1-\beta_1\beta_2) = v_1 - v_2$$

$$v_2 - v_2\beta_1\beta_2 = v_1 - v_2$$

$$v_2 - v_1\beta_2^2 = v_1 - v_2$$

$$2v_2 = v_1 + v_1\beta_2^2$$

$$2v_2 = v_1(1+\beta_2^2)$$

$$v_1 = \frac{2v_2}{1+\beta_2^2} \tag{8}$$

Substituting the solution for v_1 into the conservation of momentum formula (3) gets

$$m = \frac{m_0 v_2}{v_1 - v_2} = \frac{m_0 v_2}{\frac{2v_2}{1+\beta_2^2} - v_2} \tag{9}$$

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

$$\frac{v_2}{\frac{2v_2}{1+\beta_2^2} - v_2} = \frac{1}{\frac{2}{1+\beta_2^2} - 1} = \frac{1+\beta_2^2}{2-(1+\beta_2^2)} = \frac{1+\beta_2^2}{1-\beta_2^2}$$

The denominator on the far right equality further equates as

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

The fraction itself becomes

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

The fraction or last term in the bracket on the far right side of the equality further equates, as by using equation (7) for substitution, as

$$\frac{4\beta_2^2}{(1+\beta_2^2)^2} = \left[\frac{2\beta_2^2}{1+\beta_2^2}\right]^2 = \frac{1}{c^2}\left[\frac{2v_2}{1+\beta_2^2}\right]^2 = \frac{v_1^2}{c^2} = \beta_1^2$$

Hence

$$\frac{m}{m_0} = \frac{v_1}{v_1 - v_2} = \left[1 - \frac{4\beta_2^2}{(1+\beta_2^2)^2}\right]^{\frac{1}{2}} = \frac{1}{\sqrt{1-\beta_2^2}}$$

$$m = \frac{m_0}{\sqrt{1-\beta^2}} \quad (1)$$

Conserving Mass-Energy of Light

Verification of equation (1) was only for an inelastic collision between two equal rest masses. A more complete verification entails two unequal rest masses for both inelastic and elastic collision. Elastic collision is an inelastic collision plus the reverse of an inelastic collision, but it also involves a transfer of relative mass whereas the mass merely remains intact with regard to inelastic collision.

A more complete verification entails the absorption and emission of light, which includes a transfer of relative mass for elastic collision. The verification of two unequal rest masses is thus with regard to either reflection or absorption and emission of light energy. For simplicity the verification here is only by example.

Let unit rest mass $m_0 = 1$ of zero momentum $m_0(0) = 0$ relative to observer A absorb a photon of momentum $m_x c$ for $m_0 + m_x$ to move away from observer A at velocity .6*c* relative to observer A. The total mass before inelastic collision was $m_c c + m_0(0)$. After inelastic collision it became $(m_c + m_0)(.6c)$.

Since the total mass is conserved it equates in the manner

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

$$m_c c = .6m_c c + .6m_0 c$$

$$.4m_c = .6m_0$$

$$m_c = 1.5m_0$$

Total momentum before the collision was (1.5)(1) = 1.5 units. After the collision it became (1.5 + 1)(.6) = (2.5)(.6) = 1.5 units. Total momentum of inelastic collision is therefore conserved along with conservation of mass.

Note: Total mass before and after the collision is simply $m_c + m_0 = 1.5 + 1 = 2.5$ units, as conditional to inelastic collision.

For the reverse process of elastic collision a photon is emitted from masses $m_x + m_0$ in view of observer B relatively at rest with equal energy in the opposite direction it was absorbed from. Relative to observer B the change in rest mass m_0 and its change in velocity and momentum is thus the same emitting the photon as absorbing it. Relative to observer A, however, the new velocity of observer B calculates according to the addition of velocities formula, where v = v_1 = v_2

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

The relative mass becoming of m_0 relative to observer A is

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

The units of momentum becoming of m_0 relative to observer A are (17/8)(15/17) = 15/8.

Conservation of momentum requires these units of momentum to be equal in opposite direction. They are thus calculated according to the Doppler formula in relation to the recessional velocity between observer A and the emitting source of light:

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

The total units of mass relative to Observer A are 17/8 + 3/8 = 20/8 = 5/2, which is the same as they were for inelastic collision. Total units of momentum relative to observer A also remain as (17/8)(15/17) – (3/8)(1) = 15/8 – 3/8 = 12/8 = 3/2. Relative mass and momentum are therefore conserved with regard to the elastic collision between light and matter by way of a transfer of mass-energy between light and matter.

Inertial Space

Light is defined as having zero rest mass, but is light ever at rest? When it is reflected or absorbed and emitted by matter there is, in view of conservation laws of SRT, an exchange of relative mass. It therefore has mass.

According to GRT light moves slower in a gravitational field even though light speed is constant according to SRT. It therefore interacts with space-time as well as with matter, as to exchange relative mass with the field itself.

A condition of inertial space-time is evident with the retardation of light speed and all other events in a gravitational field. This retardation principle was derived in accordance with the Schwarzschild metric:

$$ds^2 = c^2dt^2\left(1 - \frac{2GM}{rc^2}\right) - \frac{dr^2}{1-\frac{2GM}{rc^2}} - r^2d\theta^2 - (sin^2\theta)d\varphi^2 \qquad (10)$$

The interval *ds* is with regard to invariance of the interval and *dt* and *dr* are increments of time and distance where the gravitational field of mass *M* is homogeneous, as within an infinitesimal volume of space where conditions of SRT and Newton's gravitational potential are included as part of the total effect. The square root of 2GM/r in the relativistic factor $1 - 2GM/rc^2$ is the Newtonian escape velocity of the field.

If the event in question is a photon then the difference between its actual change in position and its observed change in position (in view of the principle of simultaneity) is zero, such that ds = 0. By omitting the polar coordinates dθ and dφ the metric becomes

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

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

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

$$\frac{dr}{dt} = c\left(1 - \frac{2GM}{rc^2}\right) = c' \qquad (11)$$

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

A Covariant Mach Principle

The real significance here considered of the Schwartzschild metric is that it indicates an inertial property of space. A particular property of space is thus that of a mass medium for mass-energy. As to how ordinary matter can move freely through it, except for its relative retardation effect, is because matter is wavelike, as indicated by the wave effects of matter found by Louis de Broglie. Matter thus propagates through space as waves of energy.

If matter is also a medium for sound, light and whatever, what, then, is the distinction between ordinary matter and space?

Consider matter as an anomalous condition of the space-time continuum in direct relation to gravity such that there would be no gravity if all mass were distributed evenly throughout space. There is, for instance, zero Earth gravity at Earth's center. It only occurs because of mass superposing on inertial space as an anomalous condition of it.

The anomalous and inhomogeneous condition of space as being conserved further provides an interpretation of the Mach principle according to principles of equivalence and general covariance of GRT. By the Mach principle the inertial property of mass is determined according to the relative distribution of mass as a whole. By general covariance this unevenness in the distribution of mass has the same effect regardless of where it occurs in the universe. General covariance thus merely conditions the Mach principle according to conservation of mass-energy and Einstein's interpretation of the principle of equivalence.

These conditions allow for an explanation of gravity as a contiguous action of inertial space. Mass as an anomalous condition of space and a medium for the propagation of mass-energy is also an equilibrium state of existence for gravity. Indeed, if the anomaly of inertial space is maintained by reflection of radiation, if more reflections occur in proportion to the anomaly of mass in the gravitational field, and if particles of mass move by superposition through the inertial space of the field, then the gravitational effect is thereby explained as contiguous action of reflecting or absorbing and emitting radiation.

The Cosmic Coincidence

There is, however, a Cosmic Coincidence to reckon with. The value of the Hubble Constant, as calculated from the data collected by WMAP, is 70.5 ± 1.3 km/sec/Mpc. This value times the diameter $2r_a$ of the hydrogen atom divided by light speed equals the ratio between the gravitational and electrostatic potentials Gm_a/r_a and e^2/m_ar_a for the mass of the hydrogen atom.

The proton and electron are the two fundamental masses of the smallest atoms. The electron has about 1836.15 times less mass than does the proton, or the nucleus of the hydrogen atom. The radius of the nucleus is also about 1836.15 times shorter than the radius of the hydrogen atom. Since the mass of the proton is only about one part in 1836.15 equal to the mass of the hydrogen atom, the Cosmic Coincidence approximates to the Hubble Constant times the diameter $2r_n$ of the nucleus of hydrogen atom divided by light speed equaling the ratio of gravitational and electromagnetic forces or potentials between of the proton and electron of the hydrogen atom. By substituting the product $m_ec^2r_e$ (as the electron mass m_e = 9.10938215(45) x 10^{-28} grams, light speed c = 2.99792458 x 10^{10} cm/sec and electron radius r_e = 2.8179402894 x 10^{-13} centimeters as parameters in place of the electrostatic charge unit squared, e^2 = 23.07 x 10^{-20} per second square of grams times centimeters) the ratio of forces takes the form

$$\frac{Gm_pm_e}{e^2} = \frac{Gm_p}{r_ec^2} = 4.4 \times 10^{-40} \qquad (12)$$

The value of equation (12) also approximates to the Hubble Constant with regard to the nuclear radius r_n and light speed in the manner

$$\frac{2H_1 r_n}{c} \approx \frac{Gm_p}{r_e c^2} \tag{13}$$

The left side of equation (13) is linear whereas the right side is quadratic, but by multiplying both sides by $2r_e c$ and dividing them by $4r_n$ the approximation on the right further transforms into a form whereby the quadratic part is interpreted as a relativistic factor:

$$Hr_e \approx \frac{2Gm_p c}{4r_n c^2} = \frac{c - c\left(1 - \frac{2Gm_p}{r_n c^2}\right)}{4} \tag{14}$$

Equation (14) relates to the difference in light energy after its spectrum has been gravitationally Doppler shifted.

If the observable part of the universe is limited to R = H/c, then equation (13) further relates in the manner

$$\frac{e^2}{R} \approx \frac{Gm_p m_e}{2r_n} = \frac{1}{2} m_e v_e^2 = \frac{1}{2} m_p v_p^2 \tag{6}$$

The electric charge of the electron, as spread throughout the observable universe, thus appears related to the kinetic energies of the proton and electron in relation to the gravitational Doppler shift of light spectrum and the Hubble Constant.

Cosmic Implications

The radius R implies a finite universe. Perhaps it only represents the finite-visible part of an infinite universe. The visible part would then compare to that of a black hole, assuming the black hole also represents a finite-visible universe to observers inside it.

Consider equal systems of mass gravitating towards a common center. As they converge their overall radius of separation decreases for a total gravitational increase in potential at their outer boundary. In view of Einstein's interpretation of the principle of equivalence observers in free fall observe no change in mass.

How, then, is it possible that mass density cannot result in a singularity by increasing without limit?

The singularity is avoided by way of relativistic space-time expansion. By GRT both the relative motion of ordinary matter and the speed of light are slow by the square of the relativistic factor in relation to the escape velocity of gravity. Relative motion of a body of mass in rotation is also constitutive of clock, which in the field is also slow as to nullify the slowness of light speed and other relative motion. Distances between systems would therefore be measured the same as if they exist in gravitationally free space. Consider, however, there is a relativistic decrease in radius of each system. Systems thus rotate shorter distances for only a relativistic slowing instead of a relativistic squared clock slowing. The distance between systems would then be perceived as relatively greater.

A relativistic only retardation of clocks further allows for a cut-off factor at the square root of one-half light speed in relation to the upper limit of the escape velocity. The square root of one-half light speed is here unique because observers in the field determine it as

$$\frac{c\sqrt{1/2}}{\sqrt{1-\frac{2GM}{rc^2}}}=\frac{c\sqrt{1/2}}{\sqrt{1-1/2}}=\frac{c\sqrt{1/2}}{\sqrt{1/2}}=c$$

An observable part of the universe is therefore closed relative to observers inside it.

The same universe also closes to observers outside it because of a decrease in light energy per distance according to the value of the Hubble Constant. If the radius of a black hole is, say, twice that of another, then the value of the Hubble Constant would also be one-half as much. However, distance is relative. The cut-off limit is somehow fixed to the value of the Hubble Constant. If mass continues to enter into a black hole, such as to cause an increase in the value of the Hubble Constant, the increase in value of the Hubble Constant is nullified with regard to the perception of a relative increase in size of the black hole. Consequently black holes within black holes, or universes within universes, maintain as relatively the same as all others.

Of final note: Why do large dark regions of space indicate the presence of black holes?

It is because the light energy within the black holes converts to the cosmic microwave background energy continually scattered this way and that to supply energy for the gravitational effect.