Thermodynamic Foundations of General Relativity (The Primary Gas Representation of Particle –X)

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Abstract

The author after introducing the concept of the vean (vacuum energy absorption) process shows that it not only crystallizes the progressive nature of time but also causes gravitation and the red shift of light emitted by far off galaxies [1]. He now shows that the thermodynamics of the primary gas in a gravitational field leads to the principle of equivalence and to its field equations of general relativity. The curvature of the space-time is seen to emerge from the anisotropy of the fluctuations in the Higgs field in the neighborhood of a massive body arising from the vean process. According to him unlike the currently accepted interpretation of general relativity the gravitational field based on the vean process does not exhibit non-linearity.

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1 Introduction

We saw that a particle like electron could be represented by a standing half wave called “staphon” which is formed by the confinement of a single circularly polarized luminal wave called “photino” [2][3][4][5]. The states occupied by the staphon successively in time by its interactions with the fluctuations in the Higgs field (vacuum fluctuations) was seen to form a gas called the primary gas whose microstates are occupied successively in time unlike that of real gas which are occupied simultaneously. The thermodynamics of the primary gas led us to the action entropy equivalence [6]. While the primary gas approach treats time as real, the quantum mechanics treats time as imaginary. However, it is observed that both approaches represent the same reality but with different perspectives and this symmetry is called the Wick symmetry [7]. In fact, it was shown that quantum mechanics could be understood in terms of the statistical mechanics of the primary gas where time has not lost its directional symmetry [8]. The basic postulates of quantum mechanics are found to be compatible with the primary gas representation of a particle.

We saw that time which possesses directional symmetry at the microscopic world loses it at the macroscopic level due to the vean process [9]. The vean process is introduced as a natural outcome of the interactions of the photino with the fluctuations in the Higgs field that confines it and forms the standing wave. An infinitesimal part of the energy of the fluctuations is assumed to be converted into random translational motion of the standing wave which is never returned to it. The resulting jiggling motion could be treated as some sort of quantum heat. This absorption of the vacuum energy by the particles is what we call the vean process. It was shown that the gradient in the fluctuations of the Higgs field caused by the vean process in the neighborhood of a massive body creates the gravitational field [1]. In fact, it was shown that a test mass in a gravitational field would be subject to a mass loss whose energy will be exactly equal to the kinetic energy gained by it in a free fall from infinity to that point. In other words, the rest mass of a particle could be treated as a gravitational potential. It also became clear that the space-time is the creation of the Higgs field which also creates mass by confining the photino to form a standing wave. Therefore it becomes quite obvious that gravitation which is a direct outcome of the gradient in the Higgs field and space-time are closely related. We shall now briefly review general relativity which treats gravitation in terms of the curvature of space-time and examine how the vean process matches up with it. In the treatment we would assume that all matter is constituted by a single basic particle having the confined photino structure. Actually this is not true because we have to consider two types of particle which constitute any atom, namely quarks and electrons. We shall ignore this aspect for the present and assume that there is only a single constituent particle which is represented by the staphon.

2 A Review of the general theory of Relativity

Einstein approached the general theory of relativity starting from the principle of equivalence [10]. According to this principle, if in a small region in space, the gravitational field can be transformed out by selecting a frame of reference having suitable linear acceleration. Another way of stating the same thing is that if we take a frame of reference that is undergoing a free fall in a small region of a gravitational field, then, an observer in that reference frame will not experience any gravitation. But this applies to only a very small region. If the region in question is not small, then the tidal forces that squeeze bodies laterally will be experienced. In other words the linear acceleration would be able to replace the gravitational field only in a very small region.

Let us now take a free falling frame of reference in a small region. Then it may be possible to scaffold a Minkowskian four-dimensional space-time coordinates in that region as it represents a gravitation free space-time for the observer on the reference frame. Here the Minkowskian nature of the space-time in a small region around the first point could be expressed as

$$dx_o^2 - dx_1^2 - dx_2^2 - dx_3^2 = d\tau^2 \tag{1}$$

This relationship is represented again in the tensor form by

$$g_{ik}\, dx^i dx^k = d\tau^2 \tag{1A}$$

Here g_{ik} is called the metric tensor or just the metric. The metric at a neighboring point may be represented by the relation

$$g'_{ik}\, dx'^i dx'^k = d\tau'^2 \tag{1B}$$

as the metric at one point would be slightly different from that at the next.

The fact that it is possible to scaffold a Euclidean coordinate system does not mean that the space defined by the frame of reference in a small region under free fall is a flat one. As already discussed, the lateral squeeze will be perceptible in such a frame. However, since this variation is of the second order, they can be ignored. But since the curvature of space is defined by the second order variations in the metric, this would mean that the frame of reference under free fall could be attributed a curvature. It is similar to treating an infinitesimally small region of the curved space as a tangential surface which is plane to the first order differentials. Einstein proposed that the metric of the space-time at a particular point in the gravitational field can be used to represent the gravitational potential, based on the insight that the gravitational field manifests itself as curvature of the four dimensional space-time. Here we should keep in mind that if we take a frame of reference having linear acceleration in the x-direction, then, for a stationary observer far away from the gravitating mass, the x-coordinate of the moving reference frame will curve into the fourth dimension which is that of time.

Einstein now proposed that the gravitational field at a point can be related to the curvature of space-time at that point which in turn has to be related to the mass density at that point (mass density has to be calculated by the mass enclosed by a sphere where the point in question falls on the surface of the sphere and the gravitating mass at its centre). Since mass is a scalar, while curvature is represented by a tensor, Einstein decided to use the stress energy tensor $T_{\mu\nu}$ instead of mass as the causative factor for gravitation. In order to implement this program, the Riemann curvature tensor which is a tensor of 4^{th} rank had to be reduced to the 2^{nd} rank curvature tensor $R_{\mu\nu}$ which is called the Ricci tensor. However, $R_{\mu\nu}$ could not be equated to the stress energy tensor because the divergence of $R_{\mu\nu}$ is not zero while that of $T_{\mu\nu}$ is zero. To overcome this problem, a new tensor known as Einstein's tensor had to be introduced given by

$$G_{ik} = (R_{ik} - \tfrac{1}{2} g_{ik} R) \quad (2)$$

Divergence of this tensor is zero. Therefore this tensor could be taken to be proportional to the stress energy tensor, $T_{\mu\nu}$ without any problem with $8\pi G/c^4$ as the constant of proportionality.

ie;
$$G_{ik} = 8\pi c^4 G T_{\mu\nu} \quad (2A)$$

The stress energy tensor accounts for all possible energy that a macroscopic body could possess. Here we ignore the cosmological term which was introduced as an after thought by Einstein.

Einstein arrived at this result starting from the Poisson equation for the gravitational field [11] given by

$$\nabla^2 \phi = 4\pi G \rho \quad (3)$$

He knew that if ϕ could be identified with the metric of the space time, then the second order differential on the left hand side of the above equation could be identified with the curvature of the space-time. Here ρ is the rest-mass density. In this way, (2A) would be the more general version of (3). Note that since (2A) is a tensor equation, it would hold good in any frame of reference which would include non-inertial ones also. That is the property of the tensor equations. If a tensor is zero in one frame of reference, then it will be zero in all frames of references. This would mean that the basic tensor equation that describes the gravitational interactions would have the same form irrespective of the frame of reference of the observer. This property is called the generalized covariance.

3 Vean Process and the Principle of Equivalence

We know that when a particle undergoes free fall from a stationary state at infinity to a point at a distance r from the gravitating mass (its centre), the total energy of the system remains unchanged. That is to say, if E_o is the rest energy of a particle at infinity and E_{ro} its rest energy at a distance r from the gravitating mass and v its velocity of free fall at that point, then we have

$$E_r \quad = \quad E_{ro}\sqrt{(1-\beta^2)} + þ_r \mathbf{v} \quad = \quad E_o \tag{4}$$

where $þ_r$ is the momentum of the free falling particle at the point under consideration. Let us now take the variations when r changes to (r-Δr). We should keep in mind that E_r is a constant in a free fall while E_{ro} varies with r. Therefore, we obtain

$$\Delta E_r \quad = \quad -\gamma E_{ro}(\mathbf{v}/c^2)\,\Delta\mathbf{v} + \Delta E_{ro}\sqrt{(1-\beta^2)} + þ_r\,\Delta \mathrm{v} + \mathrm{v}\,\Delta þ_r$$

$$= \quad \Delta \mathrm{E}_{ro}\sqrt{(1-\beta^2)} \; + \; \mathrm{v}\,\Delta þ_r \tag{4A}$$

Note that here the variations in v get cancelled out on the right hand side. This means that

$$\Delta E_r \quad = \quad (\Delta \mathrm{E}_r)_{\mathbf{v}} \tag{4B}$$

This allows us to take v to be a constant in the small region in a gravitational field. In the approach followed above we have taken only the free fall velocity under consideration. However, it can be shown that the relation (4B) would hold good even for other velocities. Now recall that the space-time coordinates can be expressed in terms of the properties of the primary gas by the relations, $\mathbf{r} = h\mathbf{v}/K\theta$ and $t = h/K\theta$. The constancy of v in the small region means it is possible to scaffold a four dimensional Minkowskian space in that region. We know this is the essence of the principle of equivalence.

It is now possible to understand the thermodynamic basis of the principle of equivalence. We observe that when it moves with a uniform velocity, a particle is not able to balance the internal momentum of the confined composite wave (photino in the case of electron) with that of the fluctuations in the Higgs field. However, when the particle undergoes acceleration, it is able to balance the momentum of the confined wave with that of the fluctuation waves. In other words, the accelerated motion of the particle allows it to achieve equilibrium with the fluctuations in the Higgs field. ***Therefore, a particle (represented by the primary gas) under a free fall could be treated as a gas in equilibrium with the fluctuations in the Higgs field in that small region.*** The fact that $dE = (dE)_{\mathbf{v}}$ in a small region and also that the primary (broglieon) gas remains in thermal equilibrium with the fluctuations means that it is equivalent to another primary gas having suitable rest mass and uniform velocity in a gravitation free region. Recall that special theory of relativity deals with systems which are in equilibrium with the fluctuations in the Higgs field [5]. This means that in that small region we could apply special relativity and this is the essence of the principle of equivalence. Of course, the general theory of relativity does not explicitly take into account the decrease in the rest mass of a particle in a gravitational field. But actually this aspect has been accounted for in the slowing down of the clock in a gravitational field. This mass loss by the test particle does not in any way affect the validity of the field equations of the GR.

Since we could scaffold a Minkowskian space-time in a small region in a gravitational field, it is obvious that the energy-momentum equation of the special relativity would also hold good here. That is

$$E'^2 - þ'^2 c^2 \quad = \quad E_o'^2 \tag{5}$$

where E'_o is the rest energy of the particle at a distance r from the gravitating mass. The corresponding relation for the internal coordinates is given by

$$c^2 T'^2 - X'^2 \quad = \quad c^2 T_o'^2 \quad where \quad T_o' \; = \; h / E_o' \tag{6}$$

We know that we could extend this relation to the external four-dimensional coordinates by multiplying both sides of the equation by N and n where N denotes the number of microstates in the primary gas state while n stands for the number of primary gas states in the duration under consideration [6].

$$c^2 t'^2 - x'^2 \quad = \quad c^2 t_o'^2 \quad where \quad t' \; = \; nN\,T' \tag{7}$$

In the three dimensional case, this could be expressed in a more convenient notation as

$$x_o'^2 - x_1'^2 - x_2'^2 - x_3'^2 \quad = \quad \tau'^2 \tag{7A}$$

Here τ' is the four dimensional distance in the proper reference frame of the particle at a distance r from the gravitating mass. For infinitesimally small space-time region, the above equation can be written using the metric g_{ik} as [1]

$$g_{ik}\, dx'^i dx'^k \quad = \quad d\tau'^2 \tag{7B}$$

This shows that when we say that the space-time is Minkowskian in a certain region, what it means is that the internal coordinates of a particle will be Minkowskian if it is located in that region. We should keep in mind that the space-time has no existence by itself except though the interactions with the material particles which occupy it.

We may now express the relativistic energy momentum relation also using the metric as

$$g_{ik}\, þ'^i þ'^k \quad = \quad E_o'^2 / c^2 \tag{8}$$

Here E'_o represents the rest energy of the particle in the proper frame in that small region of gravitational field. Since $\Delta x'^i = \Delta nNX'^i$, where X'^i is the corresponding inner coordinate, we may re-express (7A) in terms of the internal space-time coordinates as

$$g_{ik}\, X'^i X'^k \quad = \quad \breve{\tau}'^2 \tag{9}$$

where $\breve{\tau}'$ is the intrinsic aspect of τ'. Here $\breve{\tau}'$ denotes the intrinsic four dimensional distance in the proper reference frame. If the space is Minkowskian, then we know [6] that

$$E' T_e' - þ_x' X_e' - þ_y' Y_e' - þ_z' Z_e' \quad = \quad h \tag{10}$$

This could be expressed using the metric as

$$g_{ik}\, þ'^i X'^k \quad = \quad h \tag{10A}$$

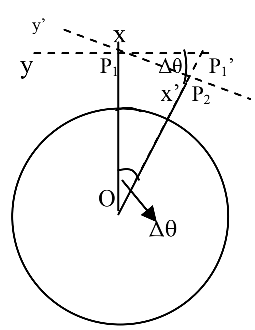
The relations (8) and (9) are derived based on special theory of relativity which is applied to the gravitation free regions. But we know from the principle of equivalence that we could apply special relativity in a small region in a gravitational field.

We know that the rest energy given on the right hand side of the (8) decreases as the strength of the gravitational field increases. On the other hand the four dimensional distance increases as the strength of the gravitational force increases. Equation, (10) represents the fact that the product of these would be a constant. It will be shown that the variation in the magnitude of the four vector X' can be attributed to the curvature in the space-time.

4 The Vean Process and the Curvature of Space-time

We already saw how a large mass creates anisotropy around it which results in a gradient in the energy of the Higgs field. It is easy to relate this gradient to the curvature of the space-time. If we assume that a particle is undergoing free fall along the x-axis of the coordinate system, then the curvature will involve the x-coordinate and the time coordinate. However since the anisotropy of the vacuum fluctuations field has spherical symmetry around the gravitating mass, the curvature in general will involve all spatial coordinates. In other words we can understand the accelerated motion of a test particle in a gravitational field as the particle's way of arriving at equilibrium with the vacuum fluctuations field.

To elucidate this point, let us take the case of two particles close to each other undergoing free fall from infinite distance towards a gravitating mass. Let one of the particles be at point P_1 at a distance r from the centre of the gravitating mass, O. For the sake of convenience we shall assume that the particle is free falling along the x-axis of the coordinate system scaffold on the particle. Let the other particle be at P_2 which also is at a distance r from O but separated by a distance Δy along the y-axis



Two masses falling freely from infinity parallel to each other along the x-axis reach point P_1 and P_2 close to the gravitating mass with centre at O. The masses are no more travelling parallel to each other. This means that the x-axis of one particle is no more parallel to that of the other. This angle $\Delta\theta$ between them represents the curvature of the space-time at P.

Figure 1

from P_1. Then we observe that the x-axis (which is the direction of free fall) at P_1 is not parallel with that at P_2 although when the particles began their journey from infinity they were parallel. The angle between these two axes can be taken as $\Delta\theta$ which is given by the relation

$$\Delta\theta = \Delta y/r \quad or \quad \rho = \Delta\theta/\Delta y \qquad (11)$$

where ρ denotes the curvature at the point. Note that as the particles keep falling Δy will decrease while Δθ will increase (note that at infinity the gravitational field is zero and it keeps on increasing in an accelerated manner as the particles keep falling bringing the particles closer) which increases ρ. Let us now assume that the two particles are two parts of a single body which are very loosely bound. The variation in the direction of the x-axis at P_1 and P_2 can only be explained in terms of the curvature of the space due to gravitation. Note that the distance P_1P_2 keeps reducing in an accelerated manner as the body keeps falling further towards gravitating mass. It is very clear from (11) that as Δy decreases, the curvature ρ increases further. This explains the curvature of spatial coordinates in a gravitational field.

If the points P_1 and P_2 belonged to a solid body, then, the coming closer of P_1 and P_2 would be resisted by the inner structure of the body. Therefore, the free falling body will undergo stress. Similarly, two points on the body separated in the radial direction also would undergo stress due to the difference in the magnitude of the acceleration. In other words, in the case of a body, unlike that of a particle, the entire energy due to the mass defect will not be converted into its kinetic energy. A small portion would get converted into stress energy.

Let us now examine what happens to a particle along the x-axis in a free fall. From (6) we know that at the point P we may write

$$c^2T'^2 - X'^2 \quad = \quad c^2T_o'^2 \tag{12}$$

Let the particle fall to a point Q after a very short interval and the variation in the internal coordinates could be expressed as

$$c^2T'\,dT' - X'\,dX' \quad = \quad c^2T_o'dT_o' \tag{12A}$$

Note that dT'_o is not zero because the internal coordinates expand infinitesimally when falling from P to Q. Here we observe that dT'_o has positive value. This variation is different from that observed in Δy. In the case of the Δy, its magnitude decreased in a free fall. This means that the curvature expressed by the relation (12A) is opposite to that of Δy. If we take the curvature in Δy and Δz as positive, the curvature as expressed in (12) is negative. A saddle type surface is a typical case of negative curvature in two dimensions while a spherical surface represents the positive curvature in two dimensions. The fact that T'_o expands as the gravitational field increases comes out of the fact that the rest energy of a particle decreases in a gravitational field since we have

$$E_o' \quad = \quad h/T_o' \tag{13}$$

From the above discussion it is quite obvious that the vean process which creates a gradient in the Higgs field results in the variation of the internal space-time of a particle which in turn gets expressed as the curvature of the external space-time.

We know that in a free fall from infinity towards a gravitating mass, the total energy of the particle remains unchanged [1]. The increase in the kinetic energy of the free fall motion of the particle is compensated by an equal decrease in the mass of the particle. In other words, in a free fall, the gravitational field does not lend any energy to the particle. Let us now take the case of a light wave traveling radially towards a gravitating mass. It is logical to assume that here also the gravitational fields does not lend any energy to the light wave. Therefore, the energy of the light wave should remain unchanged. Note that this holds good only with regard to a stationary frame of reference located at infinity. If the observer is located in a gravitational field, then, the light seen by him will appear to be blue shifted, as he is stationed in a region where time has undergone dilation. To understand the situation one has to take the case of the red shift of light of a particular spectral line emerging from the surface of a star when observed on the surface of the earth which for the purpose in hand can be taken as gravitation free region. If we now reverse the direction of light, then the light originating from the Earth will be having lower energy than what is associated with that particular spectral line. However, when it reaches the surface of the star, the energy of the light will exactly match that of the spectral line. In other words, in the local frame of reference on the surface of the star, the light would appear to gain energy. Note that the factor by which the light gets blue shifted will be inverse of the factor by which it gets red shifted. The deviation of the light by the gravitational field of the Sun could also be understood in terms of this gradient of the Higgs field which defines the curvature of space.

5 Vean Process and the Field Equations

General theory of relativity explains gravitation in terms of the curvature of space-time. The gravitating mass is assumed to curve the space-time which is felt as gravitation by the other masses and vice versa. But it does not give any explanation regarding how this takes place. In other words, the general theory does not explain the process behind the curving of space time. It does not give any idea regarding the structure of space-time and therefore it is not clear whether there is granularity at the deepest level. Since quantum mechanics deals with discrete entities, it is presumed that there should be granularity in space-time at the deepest level. Therefore, it appears that the general theory may be a macroscopic approximation of a more general theory.

Let us see how the vean process approaches the issue. We note the vean process and the interactions with the fluctuations in the Higgs field introduces granularity to the curvature of space-time. We already saw that the internal coordinates of a particle and its external projections are quantized. In the approach based on the vean process the question of the Minkoskian nature of the space-time in a mass-free universe does not becomes meaningless. This is because, we are allowed to introduces a test mass which is small enough that its effect on the neighborhood could be ignored. Therefore, it is possible to introduce the internal coordinates of space-time and with it the external coordinates of space-time can be set up.

The field equations in the general theory of relativity are derived based on the assumption that the gravitational field at a point in space is determined by the curvature of the space-time at that point represented by the second rank tensor $R_{\mu\nu}$ which in turn is directly proportional to the stress energy tensor at that point represented by $T_{\mu\nu}$.. But Einstein was disappointed to find that $R_{\mu\nu}$ could not be equated with $T_{\mu\nu}$. This is because $R_{\mu\nu}$ has a non-zero divergence while $T_{\mu\nu}$ has a zero divergence (Note that the divergence can be taken in a simple manner only in a weak gravitational field). $R_{\mu\nu}$ will have zero divergence only in flat space which would mean that the space contains no energy or mass. This basic contradiction in the theory troubled Einstein quite a lot. Ultimately to resolve the problem he had to artificially create a new curvature tensor $G_{\mu\nu}$ known after him given by

$$G_{\mu\nu} = R_{\mu\nu} - \tfrac{1}{2} g_{\mu\nu} R \qquad (14)$$

where $R = R_\mu^\mu$. $G_{\mu\nu}$ has zero divergence and therefore could be equated to the stress energy tensor $T_{\mu\nu}$ without any problem. Accordingly, taking the constant of proportionality as $8\pi G/c^4$, he wrote

$$G_{\mu\nu} = (8\pi G/c^4)\, T_{\mu\nu} \tag{15}$$

ie;

$$R_{\mu\nu} - \tfrac{1}{2} g_{\mu\nu} R = (8\pi G/c^4)\, T_{\mu\nu} \tag{15A}$$

We may now raise one index and contract it with the remaining covector index to obtain

$$R - \tfrac{1}{2} g_\mu^\mu R = (8\pi G/c^4)\, T \tag{15B}$$

where $T = T_\mu^\mu$. But we know that $g_\mu^\mu = g^{\mu\nu} g_{\mu\nu} = 4$. Therefore, we may simplify (15B) to obtain

$$-R = (8\pi G/c^4)\, T \tag{16}$$

Here for weak gravitational fields, it can be easily shown that [12]

$$R = \nabla^2\phi/c^2 = 4\pi G\rho/c^2 \tag{17}$$

where ϕ could be taken as the gravitational potential while ρ is the rest density of matter. Here Rc^2 represents the divergence of the flux density of the gravitational field across the imaginary sphere passing through the point P with the gravitating body at the centre. We know that (15A) can also be expressed as [12]

$$R_{\mu\nu} = (8\pi G/c^4)\, \breve{T}_{\mu\nu} \tag{18}$$

where

$$\breve{T}_{\mu\nu} = T_{\mu\nu} - \tfrac{1}{2} g_{\mu\nu} T \tag{18A}$$

Note that both $R_{\mu\nu}$ and $\breve{T}_{\mu\nu}$ have divergence.

Here we should keep in mind that the zero divergence of the stress energy tensor is warranted by the conservation principles of energy and momentum. That was the reason why Einstein had to modify the curvature tensor rather artificially to equate it with the stress energy tensor. But when we view the case in the light of the vean process, then we observe that the stress energy tensor has to have non-zero divergence. This is because, a gravitating body keeps on absorbing energy from the vacuum continuously and therefore the conservation principle should not hold good for a gravitating body. In other words, $\breve{T}_{\mu\nu}$ is the true representative of the gravitating body and not $T_{\mu\nu}$. Once this aspect is accepted, then the need for the introduction of the artificial curvature tensor $G_{\mu\nu}$ becomes quite unwarranted. Here we should note that the vean process does not alter the field equation proposed by Einstein. It only makes its construction more logical.

On the basis of the vean approach, it becomes obvious that the curvature of the space-time is a direct outcome of the anisotropy of the vacuum fluctuations in the Higgs field. The anisotropy of the Higgs field is a measure of the vean process which in turn is proportional to the density of the gravitating mass in that region. In that sense, the basic assumptions which lead Einstein to the field equations appear to be very well justified in the approach based on the vean process. However, for reasons already clarified, it becomes obvious that the curvature tensor and the stress energy tensor of the gravitating mass, both will have divergence. Note that the geodesic of particle in a curved space-time can be understood in terms of the path taken by a particle to keep itself in equilibrium with the anisotropic Higgs field.

When Einstein equated the curvature tensor to the stress energy tensor, his argument was, as already discussed, based on treating the metric, $g_{\mu\nu}$ as the gravitational potential. His approach was essentially a geometric one. For the same reason it did not explain the actual process involved in making the space-time curved. This is indeed a serious short coming. On the other hand, in the approach based on the vean process we have an exchange process which creates the space-time and its curvature which is more satisfying.

Although the field equations obtained in the general theory is validated by the vean approach, there is a major difference between the two approaches regarding the mass of a body in a gravitational field. We observe that according to the approach based on the vean process, the mass of a body in a gravitational field will be less than that in a gravitation free region. In other words, the rest mass of a particle is not an invariant. It decreases as the gravitational field increases. At first glance this may appear to contradict the assumptions in the general theory of relativity. In the general theory the mass of a test particle is always taken as a constant just like the charge of an electron is taken as an invariant in the electromagnetic field. It can be easily seen that this decrease in the rest mass does not play any role in the motion of the particle because of the fact that the gravitational mass is identical with the inertial mass. We observe that the general theory allows decrease in the mass in a gravitational field so long as the inertial mass also gets reduced by the same extent. We know that in that case the rest mass of the test body gets out of reckoning as it gets factored out from the equation as can be seen from (3). Therefore, the acceleration can be treated as emanating from the curvature of space-time due to the presence of the gravitating mass. This makes it obvious that the mass defect in a gravitational field will in no way affect the validity of the field equations of the general theory of relativity.

Another reason why this non-accounting of the decrease in the rest mass in general relativity does not become a major issue could be that it is already accounted by way of time dilation. We know that time slows down in a gravitational field. If we now represent a particle using its de Broglie wave, then it is obvious that the frequency of the de Broglie wave will decrease in a gravitational field which in turn will show up as decrease in the rest mass of the particle. The reason why the reduction in the rest mass has not been observed may be due to the fact that the slowing down of the clock automatically takes care of this aspect.

There is another reason why the general theory would accept mass defect. We know that we can scaffold a Minkowskian coordinate system in a small region in a gravitational field and this can be expressed by the relation

$$g_{\mu\nu} dX'^{\mu} dX'^{\nu} = d\breve{\tau}'^{2} \qquad (19)$$

This equation owes its existence to the fact that the special theory of relativity is valid in that small region. Note that as the small region is taken closer to the gravitating mass, $d\breve{\tau}'$ would become larger due to the time dilation. Now we know that going by Noether's theorem, the invariant quantity in the case of the symmetry of relativity is the rest mass [1]. But this invariance of the rest mass, just as the invariance of the four dimensional distance, applies to a small region only. But when we move the small region closer the gravitating mass, just as the four dimensional distance $d\tau'$

increases, the rest mass of a body has to decrease. Remember that there is an inverse relationship between $d\tau'$ (note that $d\tau'$ is equal to cdt'_o where t'_o is the local proper time) and the rest energy which arises out of the invariance of the intrinsic action. Therefore, the rest mass has to decrease. This is in built in the general theory although it has not been brought out explicitly in the literature.

6 Vean Process and the Linearity of the Gravitational Field

The general theory introduces the non-linearity of the gravitational field. This non-linearity arises because according to general relativity all types of energy contribute to the gravitational field. Let us take the case of the electromagnetic field which is a typical case of a linear field. In particular, we shall take the case of the electrostatic field which shows the inverse square property just like the gravitational field. Let us take the case of a sphere which contains electric charges distributed not necessarily only along the surface of the sphere. Here we know that whatever be the distribution of the charges within the sphere, the electric field outside the sphere will always remain the same. This arises out of the linearity of the electrostatic field. However, in the case of the gravitational field, the situation is not that simple. If a massive star undergoes gravitational collapse, then the increased pressure inside the star should create additional stress energy. But the general relativity says that any form of energy contributes to the curvature of space-time around it. This means that when the star undergoes collapse, the gravitational field outside the star would increase on account of the energy built up by the increased pressure. This means that a re-alignment of the masses within the star alters the gravitational field around it. This leads to the non-linear nature of the gravitational field.

When we look at the issue from the point of view of the primary gas and the vean process, then we observe that the pressure in the star collapse is created by blocking the free fall of the masses from the surface of the star. In other words, the kinetic energy of the free fall is being converted to compress the star matter which results in higher pressure. But we know from the primary gas approach that the kinetic energy of the free fall of a body in a gravitational field is created by losing its rest mass by the same proportion. This means that the energy due to the increased pressure of a collapsed star comes out of the loss of an equal quantum of energy from its rest mass. Therefore, in a star collapse, the total energy of the system neither increases nor decreases. It remains the same. This in turn would keep the gravitational field around the star unchanged and maintain its linearity.

7 Loss of Entropy in a Gravitational field

We know that the intrinsic entropy of the primary gas representing the intrinsic action of a particle remains invariant in a gravitational field [1]. This could be expressed in terms of the intrinsic action (recall the action-entropy equivalence) as

$$E_o T_o \quad = \quad E'_o T'_o \quad = \quad h \tag{20}$$

Since we can scaffold a local Minkowskian coordinate system at any point in a gravitational field, we may express the above equation as

$$g_{\mu\nu}\, \text{þ}'^{\mu} X'^{\nu} \quad = \quad E'_o T'_o \quad = \quad h \tag{21}$$

This equation would hold good in any region in the space. This relation is as fundamental as the mass energy relation E = mc^2. In fact this equation has deep connection to the least action principle. In classical as well as quantum mechanics, the action functions which we deal with are extensive ones. Therefore, when we use the least action (extensive) principle, what we minimize is the extensive aspect while the intensive aspect remains invariant.

It should be noted that the spatial coordinates appearing in (21) are the internal coordinates of the particle and should not be confused with the external coordinates. But we can convert it into the external coordinates by multiplying with nN [6]. Therefore, we obtain

$$g_{\mu\nu} þ'^{\mu} x'^{\nu} \quad = \quad E'_o t'_o \quad = \quad h \tag{21A}$$

These equations are quite different from the field equations. Here $þ'^{\mu}$ is not a part of the energy-momentum tensor of the gravitating body, but that of test particle while x'^{ν} represents its Minkowskian space-time coordinates. Therefore, it does not bring out curvature of the space-time. The curvature aspect can be brought out only if we take local Minkowskian coordinates at two points which are close by as given below and compare them.

$$g_{\mu\nu} \mathrm{d}x'^{\mu} dx'^{\nu} \quad = \quad d\tau'^2 \tag{22}$$

$$g_{\mu\nu} \mathrm{d}x''^{\mu} dx''^{\nu} \quad = \quad d\tau''^2 \tag{22A}$$

Obviously, ($d\tau'$-$d\tau''$) would be a measure of the curvature of the time coordinate into the x-coordinates. For the sake of simplicity we shall take the direction of the free fall to be along the x-axis. Note that since we are using an elementary particle as the test particle we do not have to deal with the curvature in the direction transverse to the free fall. Remember that we are representing a particle in terms of a standing wave directed along the path of free fall. This makes study of the gravitational effect on particles so much simpler as we can avoid the use of the unwieldy tensor formalism. But when we deal with macroscopic objects, we have to use the field equation in the tensor form.

We know that that when we take two particles with different rest masses, the ratio of the number of primary gas states to their rest mass remains a constant [9]. To make matters clear, let us take E_o/c^2 and E_o'/c^2 to be the rest masses of two particles and n and n′ the number of primary gas states occupied during a given time duration by an observer. In that case, we know

$$n'/E'_o \quad = \quad n/E_o \tag{23}$$

Let us now compare the case where the same two particles of the same type, say, electrons, occupy two regions in space. Let the first electron occupy a gravity free region in the outer space and let the second electron be in a region with high gravitational field. Let the observer be in the outer space where there is no gravitation. Let him receive two signals from a point in the gravitational field at time interval of t_o in his frame of reference. We can always measure the time interval in terms of the integral multiples of the intrinsic quantum of time. Note that the intrinsic quantum of time T_o of the electron is equal to h/E_o, E_o being the rest energy of the electron. Let us take the time interval to be t_o which can be taken to be equal to nNT_o in the observer's frame of reference. In the gravitational field, since the rest energy of the electron is less, we have

$$t_o \quad = \quad nNT_o \quad = \quad n'NT_o' \tag{24}$$

But since $T_o' > T_o$, we have

$$n' \quad < \quad n \tag{24A}$$

We know from (20) that the intrinsic entropy or intrinsic action of a particle remains invariant everywhere including regions having gravitational field. If we represent the intrinsic entropy of the two particles by $\hat{S}$ *and* $\hat{S}'$, then we have

$$\hat{S} \quad = \quad \hat{S}' \tag{25}$$

If we denote the extensive entropy by $S^{\#}$, then we know that $S^{\#} = nN\hat{S}$. Therefore in the light of (24A) we obtain that

$$S^{\#} \quad < \quad S^{\#'} \tag{26}$$

This means that in a gravitational field, a particle loses its extensive entropy. If the gravitational field becomes stronger, the loss of entropy will be higher. In the limit, if we take the second electron to the event horizon of a black hole, then the entropy will be completely destroyed. That is equivalent to saying that the rest mass will become zero. This means that destruction of entropy is not a unique property of the black hole. Even weaker gravitational fields have the property to destroy extensive entropy partially. The only difference is that a black hole annihilates it completely. So the difference is just a matter of degree.

Another way of viewing the same situation is to consider the standing wave structure of the particle. When a particle falls into a gravitational field, the forward wave travels longer while the reverse travel gets shorter.[6]. As the gravitating mass gets larger and larger till it becomes a black hole, the reverse wave of the particle would get compressed out of existence leaving only the forward wave. Remember that near the event horizon, the free fall velocity of a particle would become luminal velocity. In other words, the entire heat content of the particle represented by its rest energy would be converted into kinetic energy. This can happen only if the particle gets converted into a luminal wave. We know that for a particle travelling at the velocity of light, the intrinsic action (entropy) is zero.

In the above discussion on the decrease in the extensive entropy, we overlooked an important aspect. We saw that when a particle falls into a gravitating body, it gains the kinetic energy at the expense of its rest mass. This loss of rest mass has been found to be directly related to the time dilation in the gravitation field. However, the kinetic energy gained by the particle does not vanish into thin air when it falls into the gravitating body. This energy is gained by the gravitating body and we know that any energy which is confined generates its own mass. In other words, when we take the combined system of the test particle and the gravitating body, then there is no energy loss at all.

To make the picture more clear, let us assume that a very large number of particles (constituting atoms) come together due to gravitation. Initially when each of the particles were very far from each other, it could be attributed a rest mass of E_o (we shall for the sake of simplicity assume that there is only one type of particles that constitutes matter). But when they come close together, they lose part of the rest mass which gets converted into heat. Note that here the sub-quantum heat is getting converted into actual heat at macroscopic level involving random motion of particles. If the total heat generated in the process is Q and the temperature of the body formed by the coming together of the particles is θ_M , then, the entropy of the system will be given by $S_M = Q/\theta_M$. We should keep in mind that this entropy S_M belongs to the macro-level. The entropy of the primary gas representing a particle given by E_o/θ_o pertains to the sub-quantum level. This means that while the entropy at the sub-quantum level gets reduced in a gravitational field, entropy at the macro-level is simultaneously generated. We already know that if the particles had not come together to form the gravitating mass, the entropy of the system would have increased over a period of time due to the vean process [9]. The formation of the gravitating mass may not alter the situation except that part of the entropy gets shifted to the macro-level. This aspect will be studied in detail in a separate paper.

8 An Experiment to Measure the Gravitational Mass Defect

We know that the electromagnetic force is based on the virtual photons in the vacuum and it is a reasonable assumption that the gravitational field has no effect on the electromagnetic and electrostatic fields. We know that the frequency of the electromagnetic waves emitted by the hydrogen atom is given by the Balmer-Rydberg series formula:

$$\nu = \frac{m_o e^4}{8\varepsilon_o^2 h^3}\left[\frac{1}{n^2} - \frac{1}{m^2}\right] \tag{27}$$

where m_e is the rest mass of electron, e its charge, ε_o the permittivity of free space while n and m are integers. Since the rest mass appears on the numerator, it is obvious that if it decreases in the gravitational field, then it should show up as red shift in the frequency of light. Note that this red shift will be observable right in the region where the hydrogen atom is located. In the case of the red shift due to the action of the gravitational field, the observer has to be as far away as possible from the point in the gravitational field from which the light is emitted in order to measure the red shift. But in the case of the gravitational mass defect, the observer should be very close to the source of light. The problem with this is that on the surface of the Earth, the frequency shift will be by a factor as small ass 10^{-10} and it will be very difficult to measure this variation.

A better option is to introduce a torsion balance. Here the force on the torsion balance is of electrostatic nature. Therefore, while the mass gets reduced, the electrostatic force does not. Another way of looking at the problem is that in a torsion balance, the potential energy of the electrostatic field is converted into kinetic energy and back. Note that there is no change in the potential energy of the system in the transverse direction, as there is no stretching or contraction (to the first order). But the mass of the torsion balance decreases. This would speed up the velocity of the oscillations which in turn will reduce its period. Note that the time dilation would not be observed for any measurements done in the local time according to general relativity. However, this decrease in the period due to the decrease in mass would be observable in the local time itself. In other words, the period of oscillation of the torsion balance should decrease in a gravitational field. Note that the spatial dimension along the direction of the free fall would undergo expansion with the result that the electrostatic force in the torsion balance may be reduced in that direction. But along the transverse direction, the contraction in the spatial coordinates is of second order and may be ignored.

The experiment can be set up on the surface of the earth and then shifted to the top of a high mountain or in a satellite revolving round the Earth. If we observe any decrease in the period of the torsion balance, then it could be taken as a proof that the rest mass decreases in a gravitational field. Note that the slowing down of the clock due to the gravitational field will not be observable in the local time and therefore it need not be accounted in the experiment.

9 Vean Process and its implication on Cosmology

i) Mach's Principle

Mach's principle in simple term means that mass of a body depends on the distribution of other masses in the universe. His basic idea can be put in a simple manner as follows. We know from Newton's first law that

$$F = ma \;, \quad ie; \quad a = F/m \tag{28}$$

where F stands for the force, m for the mass of the body and a for its acceleration. If we consider a universe which contains no other mass, then it is impossible to measure the velocity and acceleration of the mass in question as we do not have any material object as a reference point to peg our coordinate system. Therefore, in such a universe the acceleration would become undefined. This would make mass also undefined. This line of thinking led Earnest Mach to conclude that the mass of a body will have meaning only if we have other masses around. According to him, the mass of a particle some way or other owes its existence to all the masses of the stars in the universe. However, he could never spell out how the far-away stars would determine the mass of a body.

Mach's principle was held in great esteem in the early part of the 20^{th} century. But quantum mechanics changed all that. According to quantum field theory, vacuum is no more an inert background remaining as a mute spectator, but an active participant in the interactions among the particles. In fact, it turns out that vacuum is the intermediary in all interactions. In the light of this picture it is natural that Mach's principle is no more put on a high pedestal as it used to be in the beginning of the 20^{th} century. When Einstein came out with his general theory of relativity, he was confident that it is compatible with the Mach's principle. He believed that his field equations with the cosmological term would not give null solution in the absence of any mass in the universe and therefore his general relativity would conform to Mach's principle. But he was surprised when de Sitter showed that in spite of the cosmological term, the field equations give a flat space solution in the absence of mass [13].

On the basis of the primary gas approach, we observe that a particle which is stationary or in uniform motion in a gravitation free region is in thermal equilibrium with the vacuum fluctuations. However, this does not hold good for the accelerated motion. We know that the inertia of the particle is generated by the interactions of the confined wave representing the particle with the fluctuations in the Higgs field [5]. This means that Mach's idea that inertia is created by the presence of other masses in the universe is not compatible with the primary gas approach.

ii) The Expansion of the Universe an Illusion?

We now observe that the vean process which creates the progressive time and gravitation is also responsible for the expansion of the universe. Note that the absorption of energy from the vacuum by particles alters the intrinsic quantum of time. If E_o/c^2 is the rest mass of a particle, then over a long period of time, its value may change to E_o'/c^2 where $E_o' > E_o$. This means that the quantum of time which was $T_o = h/E_o$ changes to $T_o' = h/E_o'$ where $T_o' < T_o$. Multiplying by nN, we obtain

$$t' \quad < \quad t, \tag{29}$$

This means that in the earlier epoch time would appear to be dilated compared to the time at present. The situation is similar to what we have in the case of time evolution in a gravitational field. We know from general relativity that time dilates in a gravitational field. This would mean that the red shift observed in the light emitted by the far off galaxies could actually be due to the fact that time in the earlier epoch was dilated compared to the present time. In other words, the assumption that galaxies are hurtling away from each other at near luminal velocities may be quite unwarranted. Note that the concept of the exploding universe from a singularity appears to be quite inadequate to explain the observed increase in the rate of expansion of universe over time. The current theories of gravitation would require that the expansion slows down over a period of time. In fact to explain the increase in the rate of expansion of the universe it became necessary to postulate the existence of dark matter which is attributed all sorts of properties. In fact the picture of the dark matter starts looking more and more like that of the ether a century back. Thus it is obvious that the basic process that creates gravitation also produces the expansion of universe. This is quite obvious from the fact that Einstein's field equations directly leads to a universe which is expanding. The additional bonus we have got here is that even the creation of the progressive time could be traced to the same process.

The vean process provides us with a very simple explanation for the observed red shift of the light emitted by the distant galaxies and also the increase in the rate of apparent expansion of the universe. The most surprising result of the approach based on the vean process is that now we may not need the Bing Bang theory to explain the origin of universe. The reason is simple. If the apparent expansion of universe could be attributed to the increase in the rest mass of the particles over a long period of time, then the initial galaxies need not have originated from a single point in a massive explosion. Particles could shimmer into existence gradually like dew which starts from the condensation on a small dust particle and then grows into a drop. In fact the beginning of the universe may have to be traced when particles and anti-particles got separated. We shall discuss about it in the next section. The problem with the big bang theory is that it assumes the nature of space-time and mass to remain the same even in the earlier epoch. These assumptions may be quite unwarranted

iii) The Reason Why the Universe Has No Anti-particles.

This study of the progressive time brings out a very interesting aspect into focus. We know that an electron-positron pair can be created by a high energy photon only in a virtual manner in the absence of a field. This is because a field is required to balance the momentum of the initial and the final states. However, if a large number of particles are created simultaneously, then, this requirement of the field can be avoided. The rest of the particles created simultaneously could ensure that the momentum is conserved in the process. Let us imagine that a large number of particles and anti-particles are created at the same instant. We should understand that time exist in the imaginary or reversible state at that instant [8]. The group of particles could evolve along all possible paths and jump back in time. Here a very interesting phenomenon takes place. All those paths in which the particles and anti-particles do not get segregated would not be able to last long. The particle-antiparticle collision would take place leaving no particles behind.

But some paths which involve segregation of particles and antiparticles into separate groups could survive. This is because these groups are able to move forward in progressive time by resorting to the vean process. Once this happens, the worlds of particles and the antiparticles created at the beginning move apart. The world of the antiparticles moves backward in time (regressive) while the world of particles moves forward in progressive time. Note that in the absence of the vean process, the world would have remained in the imaginary time in an unmanifested state. The world proposed by Everett belongs to the imaginary time having no vean process to break its symmetry. Obviously, such a world would remain in an unmanifested state.

It is interesting to see that the vean process gives such a simple and cogent explanation as to why our world contains only particles and no antiparticles. The vean process breaks the symmetry between particles and antiparticles and sets up a world in progressive time full of only particles. Here we have started with high energy photons as the starting point. We do not know how these photons got created. Could they also be created by way of a fluctuation? It is quite logical. The high energy photons created by the fluctuations would also have evolved along various paths before getting dissolved into vacuum. But of all these paths, the path which created the progressive time could survive because on these paths there is no going back. We should keep in mind that the creation of the high energy photons would take place in the imaginary time and not in the progressive time. Therefore, when we extrapolate the progressive time backward, the origin of time would be at the point when the particles get grouped and the vean process gets set up.

We have another possibility which is thrown open for discussion. This possibility is based on the idea that the rest mass of the particles could have been smaller in the earlier epoch. This would mean that if we extrapolate time backward adequately, the rest mass of the particles could become close to zero. In that case, the creation of the particle-antiparticle pair could have taken place without the high energy photon. This would mean that the particles which constitute the universe shimmered into existence gradually. We already saw that the vean process would result in the compression of the quantum of time as time progresses which in turn will give the appearance that the universe is expanding. In this case, we do not have to assume the existence of high energy photons as the starting point which makes it more elegant. But then we have to find explanation for the existence of the background radiation at 2^{o}K which is taken as a proof for the big bang origin of the universe..

10 The Primary Gas Structure of the Particle and the Black hole

The primary gas structure of particles may call for a radical change in the concept of the black hole. In fact, it introduces a whole new way of looking at the black hole. The idea that very massive stellar bodies can undergo gravitational collapse is compatible with the primary gas approach. It only means that the gravitating mass is so dense that fluctuations in the Higgs field which creates the reverse wave by reflecting back the forward wave (thereby forming the standing wave) gets destroyed by the negative potential generated by the vean process undergone by the gravitating mass. In other words, the standing wave representing the particle does not get formed instead it ends up as a simple forward wave or photino. But if the law of the conservation of charge is to hold good, the particle cannot end up as a photon or luminal wave. May be, the particle would never fall into the black hole, instead it may revolve round the black hole close to the event horizon. This reminds us of the electron which never falls into the nucleus due its wave nature.

The primary gas approach offers a new way of studying the properties of the black hole. It is interesting to note that a gravitating body absorbs energy from vacuum through the vean process and in that sense we may assume that a particle with mass acquires a negative temperature provided we assume that vacuum is at zero degree. The vean process could be understood in terms of the flow of sub-quantum heat from a system at higher temperature to one at a lower temperature. It is possible that when the black hole is formed, there is a sudden phase change due to the change brought out in its inner structure. Its temperature may undergo a discontinuous change from negative to positive temperature. This may be another way of looking at the Hawking radiation provided Hawking radiation is compatible with the primary gas approach. Remember that according to the primary gas approach the rest mass of a particle near the event horizon would become zero. This would mean that the probability for the pair production may increase substantially in that region. A detailed study of the black hole on the basis of the primary gas approach may bring out very interesting results.

11 Conclusion

From the above discussion we observe that the general relativity could be explained on the basis of the primary gas representation of the particle and the vean process. The field equations also emerge naturally by equating the curvature to the energy density. Here we do not have to modify the curvature tensor arbitrarily in order to equate it with the stress energy tensor. This is because the stress energy tensor is not actually a zero-divergence tensor. The vean process introduces divergence to it and we know that the expansion of the universe could ultimately be traced to this divergence. The expansion itself does not mean that the universe emerged from a singularity in a tremendous explosion. Such an idea presupposes that mass would remain unchanged through out the earlier epochs while time would display no dilation or contraction. These assumptions appear to be quite unwarranted. The vean process picture may support the case where mass condenses from vacuum gradually and the universe comes into existence in a slow and gradual process. Besides, it explains why the expansion of the universe is accelerating.

The interpretation of gravitation based on the vean process explains why it is unique compared to the other forces. While other forces operate in imaginary time, the gravitational field operates in the progressive time. Another important aspect that emerges from the primary gas approach is the concept of space-time. It is observed that the origin of space and time can be traced to the interactions undergone by the particle with the Higgs field. Remember that we had obtained the relation $T_e = h/K\theta_e$ and $X_e = vT_e$ where T_e and X_e are the intrinsic time and space of the particle while $K\theta_e$ is the average energy of interactions undergone with the vacuum fluctuations, θ_e being the temperature. We observed that the external time and space can be constructed from these internal coordinates [6]. The reason why space-time extends to infinity could be traced to the fact that the Higgs field is a long range field. By the same reasoning, we should attribute properties of internal space and time to other fields also. If these fields act independent of each other, then their respective internal space coordinates will have to be taken as constituting independent dimensions. When externalized, they would form independent spatial dimensions. But if the field is short ranged, the corresponding space also may become short ranged. This gives a very simple explanation for the existence of eleven dimensional space of the string theory. The proposed 11 dimensions only mean that there are so many field components which are independent of each other. The concept of the space warping into itself would express just the short range nature of the field.

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