Thermodynamic Foundations of General Relativity

V.A.I. Menon,
Gujarat University Campus,
Ahmedabad-380009, India

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 principle of equivalence on which the general theory of relativity is based can be understood in terms of the thermodynamics of the primary gas. The curvature of the space-time is seen to emerge from the anisotropy of the vacuum fluctuations background 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 can be represented by a confined helical wave (CH wave) formed by imparting half spin to the plane polarized electromagnetic wave [2][3][4][5]. The states occupied by the CH wave successively in time by its interactions with the vacuum fluctuations was seen to form a gas called the primary eigen gas whose microstates are occupied successively in time unlike that of real gas which are occupied simultaneously. The thermodynamics of the primary eigen gas led us to the action entropy equivalence [6]. While the primary eigen 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 can be understood in terms of the statistical mechanics of the primary eigen 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 helical wave with the vacuum fluctuations that confine it. An infinitesimal part of the energy of the vacuum fluctuations is assumed to be converted into random translational motion of the CH wave which is never returned to back to vacuum. The resulting jiggling motion can 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 vacuum fluctuations 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 would 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 can be treated as a gravitational potential. It also became clear that the space-time is the creation of vacuum fluctuations background. Therefore it becomes quite obvious that gravitation which is a direct outcome of the gradient in the vacuum fluctuations background, and space-time are closely related. We shall now briefly review general theory of 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 it is assumed that all basic particles could be represented by CH waves formed by the confinement of some composite helical wave [6]

2 A Review of the general theory of Relativity

Einstein approached the general theory of relativity (GR) starting from the principle of equivalence [10]. According to this principle the gravitational field in a small region in space 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 pull the body apart will be experienced. In other words the linear acceleration will 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. The Minkowskian nature of the space-time in a small region around the first point can be expressed by

$$g_{\mu\nu} dx^{\mu} dx^{\nu} = d\tau^2 \tag{1}$$

where $g_{\mu\nu}$ is called the metric tensor or just the metric. The metric at a neighboring point may be represented by the relation

$$g'_{\mu\nu} dx'^{\mu} dx'^{\nu} = d\tau'^2 \tag{2}$$

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. The variation in the metric is of the second order and can be ignored in a small region. But since the curvature of space is defined by the second order variations in the metric, this means that the frame of reference under free fall can 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 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 used 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

$$G_{\mu\nu} = (R_{\mu\nu} - \tfrac{1}{2} g_{\mu\nu} R) \tag{3}$$

Divergence of this tensor is zero. Therefore this tensor was 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;

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

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

Note that since (4) 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 means that the basic tensor equation that describes the gravitational interactions will 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 [1]. 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

$$E_r \quad = \quad E_{ro}\sqrt{(1-\beta^2)} + \text{þ}_\text{r}\mathbf{v} \quad = \quad E_o \tag{5}$$

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

$$\begin{aligned} \Delta E_r \quad &= \quad -\gamma E_{ro}(\mathbf{v}/c^2)\,\Delta\mathbf{v} + \Delta E_{ro}\sqrt{(1-\beta^2)} + \text{þ}_\text{r}\,\Delta\text{v} + \text{v}\,\Delta\text{þ}_\text{r} \\ &= \quad \Delta\text{E}_\text{ro}\sqrt{(1-\beta^2)} \;+\; \text{v}\,\Delta\text{þ}_\text{r} \quad = \quad 0 \end{aligned} \tag{6}$$

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

$$\Delta E_r \quad = \quad (\Delta\text{E}_\text{r})_\mathbf{v} \tag{7}$$

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 is obvious that the relation (7) will hold good whatever be the velocity of the particle. Now we may recall that the space-time coordinates can be expressed in terms of the properties of the primary eigen 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 CH wave with that of the vacuum fluctuations. However, when the particle undergoes acceleration, it is able to balance the momentum of the confined wave with that of the vacuum fluctuations. In other words, the accelerated motion of the particle allows it to achieve equilibrium with the vacuum fluctuations background. Therefore, a particle (represented by the primary eigen gas) under a free fall can be treated as a gas in equilibrium with the vacuum fluctuations background in that small region**.** The fact that $dE = (dE)_\mathbf{v}$ in a small region and also that the primary eigen gas remains in thermal equilibrium with the fluctuations means that it is equivalent to another primary eigen 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 vacuum fluctuations background [4]. This means that in that small region we may apply the principles of 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 as the mass of the test particle gets factored out there.

Since we can 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 will also hold good here. That is

$$E'^2/c^2 - þ'^2 \quad = \quad E_o'^2/c^2 \tag{8}$$

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

$$c^2T'^2 - X'^2 \quad = \quad c^2T_o'^2 \quad where \quad T_o' \quad = \quad h/E_o' \tag{9}$$

We know that this relation can be extended 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 eigen gas state while n stands for the number of primary eigen gas states in the duration under consideration [6].

$$c^2t'^2 - x'^2 \quad = \quad c^2t_o'^2 \quad where \quad t' \quad = \quad nNT' \tag{10}$$

If we take the three dimensional space and time, this can be expressed in a more convenient notation as [1]

$$g_{\mu\nu}dx'^{\mu}dx'^{\nu} \quad = \quad d\tau'^2 \tag{11}$$

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

$$g_{\mu\nu}þ'^{\mu}þ'^{\nu} \quad = \quad þ_o'^2 \tag{12}$$

Here $þ'_o = E'_o/c$ where E'_o is 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 intrinsic coordinate, we may re-express (11) in terms of the intrinsic space-time coordinates as

$$g_{\mu\nu}X'^{\mu}X'^{\nu} \quad = \quad \hat{\tau}'^2 \tag{13}$$

Here $\hat{\tau}'$ denotes the intrinsic aspect of τ'. If the space is Minkowskian, then we know [6] that

$$E'T_e' - þ_x'X_e' - þ_y'Y_e' - þ_z'Z_e' \quad = \quad E_oT_o \quad = \quad h \tag{14}$$

This could be expressed using the metric as

$$g_{\mu\nu}þ'^{\mu}X'^{\nu} \quad = \quad h \tag{15}$$

The relations (12) and (13) are derived based on special theory of relativity which is applicable to the gravitation free regions. But we know from the principle of equivalence that we can 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 (12) decreases as the strength of the gravitational field increases. On the other hand, the four dimensional distance given on the right hand side of (13), increases as the strength of the gravitational force increases. Equation, (14) represents the fact that the product of these will 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 Vean Process and the Field Equations

We saw that the accelerated motion of a test particle in a gravitational field can be understood as the attempt of the particle to attain equilibrium with the vacuum fluctuations background [1]. The variation in the intrinsic space and time coordinates of a particle as occupies at various points in such a background around the gravitating mass could be understood in terms of their curvature which in turn could be attributed to the curvature of the external space-time coordinates. It is obvious that the interpretation of gravitation in terms of the vean process is quite compatible with the approach of the General theory of relativity (GR) which explains gravitation in terms of the curvature of space-time. However GR does not offer any explanation regarding the process involved 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.

The field equations in GR 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 $G_{\mu\nu}$ named after him given by

$$G_{\mu\nu} \quad = \quad R_{\mu\nu} - \tfrac{1}{2} g_{\mu\nu} R \tag{16}$$

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

$$G_{\mu\nu} \quad = \quad (8\pi G/c^4)\, T_{\mu\nu} \tag{17}$$

ie;
$$R_{\mu\nu} - \tfrac{1}{2} g_{\mu\nu} R \quad = \quad (8\pi G/c^4)\, T_{\mu\nu} \tag{18}$$

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

$$R - \tfrac{1}{2} g_{\mu}^{\mu} R \quad = \quad (8\pi G/c^4)\, T \tag{19}$$

where $T = T_{\mu}^{\mu}$. But we know that $g_{\mu}^{\mu} = g^{\mu\nu} g_{\mu\nu} = 4$. Therefore, we may simplify (19) to obtain

$$-R \quad = \quad (8\pi G/c^4)\, T \tag{20}$$

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

$$R \quad = \quad \nabla^2 \phi / c^2 \quad = \quad 4\pi G \rho / c^2 \tag{21}$$

where ϕ can be taken as the gravitational potential while ρ is the rest mass density of matter Here Rc^2 represents the divergence of the flux density of the gravitational field across the imaginary sphere with the gravitating body at the centre. We know that (18) can also be expressed as [12]

$$R_{\mu\nu} \quad = \quad (8\pi G/c^4)\, \breve{T}_{\mu\nu} \tag{22}$$

where
$$\breve{T}_{\mu\nu} \quad = \quad T_{\mu\nu} - \tfrac{1}{2} g_{\mu\nu} T \tag{23}$$

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 the direct outcome of the anisotropy of the vacuum fluctuations background. The anisotropy of the vacuum fluctuations background 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 vacuum fluctuations background.

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 indeed is 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 in a gravitational field because of the fact that the gravitational mass is identical with the inertial mass and as a result it gets factored out from the equations. This is the reason why acceleration could be fully attributed to the curvature of space-time which in turn is caused by the presence of a gravitating mass. This makes it obvious that the mass defect in a gravitational field would in no way affect the validity of the field equations of the general theory of relativity.

Another reason why this non-accounting of the mass defect 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.

In the approach based on the vean process the question of the Minkoskian nature of the space-time in a mass-free universe does become meaningless. One may think that by introducing a test mass which is small enough to have hardly any effect in the neighborhood we may measure the Minkoskian nature of the space-time which can be attributed to the isotropy of the vacuum fluctuations background. But then we should keep in mind that in a universe without any mass, time will lose its progressive nature with the result that the universe will remain in an unmanifested or unreal state.

5 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. Therefore when the star undergoes collapse, the gravitational field outside the star will 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 eigen 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 eigen gas approach that the kinetic energy of the free fall of a body in a gravitational field is created by at the cost of its rest mass. Therefore, 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. In other words, in a star collapse the total energy of the system neither increases nor decreases. It remains the same. This in turn will keep the gravitational field around the star unchanged and maintain its linearity.

6 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 can be expressed in terms of the intrinsic action (recall the action-entropy equivalence) as

$$E_o T_o \quad = \quad E'_o T'_o \quad = \quad h \tag{24}$$

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

$$g_{\mu\nu} \text{þ}'^{\mu} X'^{\nu} \quad = \quad E'_o T'_o \quad = \quad h \tag{25}$$

This equation will hold good in any region in space. This relation is the restatement of the familiar equation E = hν. 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 (25) are the intrinsic 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 [5]. Therefore, we obtain

$$g_{\mu\nu} \text{þ}'^{\mu} x'^{\nu} \quad = \quad E'_o t'_o \quad = \quad nN\, h \tag{26}$$

These equations are quite different from the field equations. Here p'^{μ} 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.

$$g'_{\mu\nu} \mathrm{d}x'^{\mu} dx'^{\nu} = d\tau'^{2} \tag{27}$$

$$g''_{\mu\nu} \mathrm{d}x''^{\mu} dx''^{\nu} = d\tau''^{2} \tag{28}$$

Obviously, ($d\tau'$-$d\tau''$) will be a measure of the curvature of the time coordinate into the x-coordinates (taking the direction of 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 CH wave directed along the path of free fall. This makes study of the gravitational effect so much simpler as we can avoid the use of the unwieldy tensor formalism. But we should keep in mind that 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 eigen gas states occupied in a certain time interval to their rest mass remains a constant [9]. To make matters clear, let us take E_o and E_o' to be the rest energies of two particles and n and n′ the number of primary eigen gas states occupied during a given time duration as measured by an observer stationed far away from the gravitating mass. In that case, we know

$$n'/E'_o = n/E_o \tag{29}$$

Let us now compare the case of two particles of the same type, one located in a gravitation free region and the other located in a region with strong gravitational field. Since the particle loses part of its rest energy in a gravitational field, we may relate the rest energies of the two particles by E_o and E_o' and the number of eigen states n and n′ by the inequality

$$E_o' < E_o \quad ; \quad n' < n \ . \tag{30}$$

So that (29) holds good.

We know from (24) that the intrinsic action of a particle remains h which is a universal constant everywhere including in gravitational field. Based on the action-entropy equivalence [5], it is possible to take the intrinsic entropy of a particle to be K, the Boltzmann's constant. If we represent the intrinsic entropy of the two particles, one in the gravitation free region and the other in a gravitational field by $\hat{S}$ and $\hat{S}'$, then we have

$$\hat{S} = \hat{S}' = K \tag{31}$$

If we denote the extensive entropy by $S^{\#} = nN\hat{S}$, then in the light of (30) we obtain

$$S^{\#'} < S^{\#} \tag{32}$$

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 particle 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 shows that the destruction of entropy is not a unique property of the black hole. Any gravitational field has the ability to destroy extensive entropy partially. The only difference is that a black hole annihilates it completely close to the Schwarzschild radius. So the difference is just a matter of degree.

Another way of viewing the same situation is by studying what happens to the CH wave as it undergoes free fall in a gravitational field. We know that in such a free fall, the forward wave travels longer while the reverse travel gets shorter [1]. As the particle approaches the Schwarzschild radius of a black hole, the reverse wave will get compressed out of existence leaving with only the forward wave. In other words, the entire heat content of the particle represented by its rest energy will be converted into kinetic energy as 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 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 gravitational 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, each may 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 eigen 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.

7 An Experiment to Measure the Gravitational Mass Defect

We saw that in any experiment to measure the gravitational mass defect based on the force acting on a particle in a gravitational field, the net effect gets canceled out due to the fact that the gravitational mass cannot be distinguished from the inertial mass. Therefore the best option is to introduce a torsion balance as the force field involved in such a set up is of electrostatic nature. Here while the mass gets reduced, the force due to the electrostatic force does not undergo change. 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 since the mass of the torsion balance decreases in a gravitational field, this will speed up the rate of the oscillations which in turn will reduce its period. Note that the time dilation will 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 will 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 in a gravitational field the contraction in the spatial coordinates along the transverse direction will be 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 can be taken as a proof that the rest mass decreases in a gravitational field.

8 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 could be put in a simple manner as follows. We know from Newton's first law that

$$F = ma, \quad ie; \quad a = F/m \tag{33}$$

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 will become undefined. This will 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 it. 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.

When Einstein came out with his general theory of relativity, he was confident that the field equations would give a null solution for a universe without mass and therefore remain compatible with the 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]. This meant that the special theory of relativity would hold good in such a space-time and therefore the test mass would have to be attributed the property of inertia. But according to Mach's principle the test mass cannot be defined in the absence of other gravitating mass. Mach's principle was held in great esteem in the early part of the 20th 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 20th century.

On the basis of the primary eigen 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 is generated by the interactions of the confined helical wave representing the particle with the vacuum fluctuations background [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 eigen gas approach.

ii) Is the Expansion of the Universe an Illusion?

We shall now show that the vean process which creates the progressive time and gravitation is also responsible for the red shift of the far of galaxies. 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 would have changed to E_o'/c^2 where $E_o' > E_o$. This means that the quantum of time which was $T_o = h/E_o$ earlier would also have changed to $T_o' = h/E_o'$ where $T_o' < T_o$. Multiplying by ΔnN, we obtain

$$\Delta t' < \Delta t, \tag{34}$$

This means that in the earlier epoch time would appear to be dilated compared to the time at present. The situation is similar to the time dilation predicted by GR in a gravitational field. In other words the red shift observed in the spectral lines of the far off galaxies could actually be due to the fact that time in the earlier epoch was dilated compared to the present time. Therefore, the assumption that galaxies are hurtling away from each other at near luminal velocities may be quite unwarranted. The expansion of universe estimated based on the red shift of the spectral lines will have to be termed "apparent expansion".

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 predict that the expansion will slow down over a period of time. In order to explain the increase in the rate of expansion of the universe it became necessary to postulate the existence of dark matter. We now observe that the proposed approach based on the vean process while explaining the basis of the gravitational field also accounts for the observed red shift on which the idea of an expanding universe rests. Another advantage of the vean process is that even the creation of the progressive time can be traced to the same process. To top it all, the vean gravitation demands that the rate of expansion of the universe should increase exponentially in time. This is because, as the mass of all bodies increase due to the vean process, the strength of the vean process will increase proportionately and this will in turn lead to the exponential growth of mass which in turn will result in the expansion following an exponential growth pattern.

We saw that the vean process provides us with a very simple explanation for the observed red shift of spectral lines 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 can 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 drops. 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

It should be noted that this result does not invalidate the presently estimated age of the universe which is around 15 billion years. Here we should remember that we are trying to measure the time of the past epoch with the time of the present one. In the currently used estimation, the variation in the intrinsic aspect of time is not taken into account. Therefore, when we measure the length of the past epoch, we take the intrinsic time of the present epoch as a constant and extrapolate its applicability to the past epoch. This gives us a finite time. In fact it is easier to understand the situation if we take the analogy of a vessel which gets filled by water.

Let us assume that a large vessel gets filled with water at a rate which varies exponentially with time. In the beginning the vessel will be getting filled in drops which gradually increases to a trickle and then to a steady flow. Let us assume that after a long time after the filling process got commenced the vessel is filled up with 100 liters of water and the rate of filling up at a given instant is ½ liter/hour. We know that if we actually calculate the time taken for the vessel to get filled up to the 100 liters mark, it will work out to be infinite. This is so because, in the initial stage, theoretically the rate at which water gets filled will be infinitesimally small. But a naïve observer may assume that the rate of filling up of the tank does not vary at all and therefore, according to him the tap would have been opened just 200 hrs earlier $(100 \div ½ = 200)$. The conventional estimate of the age of the Universe may be suffering from a similar debility. Note that in the conventional estimate of the age of the universe, the basic property of time is assumed to remain the same whereas we observe that the intrinsic aspect of time may undergo dilation as we go backward in time. If we go by the approach based on the vean process, the age of Universe would be infinite.

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 observe that the mass of a particle has been increasing at an exponential rate due to the vean process undergone by it. This compels us to conclude that in the beginning of the universe the particles were having mass very close to zero. The probability for the creation of such particles becomes larger as the rest mass is infinitesimally small. Let us imagine that a large number of particles and anti-particles are created during this epoch. We should keep in mind that time existed in the imaginary or reversible state during this epoch [8]. The group of particles could evolve along all possible paths and jump back in time. Here a very interesting phenomenon could have taken place. All those paths in which the particles and anti-particles do not get segregated may not last long. The particle-antiparticle collision will take place leaving no particles behind.

But some paths which involve segregation of particles and antiparticles into separate groups could have survived. This is because these groups are able to move forward in progressive time by resorting to the vean process. Once vean process kicks in, 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.

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. Although the vean mechanism explains the creation of the universe with only particles, we still 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.

9 The CH wave Structure of the Particle and the Black hole

The CH wave 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. We already saw that a particle will lose its CH wave structure as it approaches the Schwarzschild radius of a black hole and will acquire the form of a luminal wave. But if the law of the conservation of charge is to hold good, the particle cannot end up as a 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 requirement of the charge conservation would demand that the charged particle does not fall just short of the Schwarzschild radius. Here the similarity of the situation to that of an electron's motion near an atomic nucleus is quite compelling. While the electron is unable to squeeze itself within the nucleus due to its spatial spread, in the case of the black hole, the particle will not be able to fall through the event Schwarzschild radius due to the fact that it would result in the break down of the conservation laws. In other words, there may not be any singularity hiding at the centre of the black hole. These aspects have to be studied in detail. Right now we are only making educated guess.

The primary eigen gas approach offers a new insight into behavior of a 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 can 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. Remember that according to the primary eigen gas approach the rest mass of a particle near the event horizon will become zero. Therefore 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 eigen gas approach may bring out very interesting results.

10 Conclusion

From the above discussion we observe that the general relativity can be explained on the basis of the vean process undergone by particle which is represented by a primary eigen gas. The field equations also emerge naturally by equating the curvature to the energy density directly. 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 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 could be traced to the interactions undergone by particles with the vacuum fluctuations background. Remember that we had obtained the relation $T_{eo} = h/K\theta_o$ and $X_{eo} = vT_{eo}$ where T_{eo} and X_{eo} are the intrinsic time and space of the particle while $K\theta_o$ is the average energy of interactions undergone by the particle in its rest frame of reference with the vacuum fluctuations, θ_o 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 may be traced to the fact that the vacuum fluctuations 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 multi-dimensional space of the string theory. The proposed multi-dimensions only mean that there are so many fields and 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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