From the Sub-quantum Thermodynamics to the Arrow of Time and the Collapse of Wave Function

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

Abstract

The author after clarifying the physical implications of the imaginary time approach and the reversible real time approach goes on to explain how they differ from the progressive time which is experienced by all macroscopic systems. He proposes that the progressive nature of time is a direct result of the increase in the entropy at the sub-quantum level. According to him just as the interactions with the vacuum fluctuations create the confined helical wave (CH wave) which is the basic structure of a particle, a small part of the energy gets converted into its jiggling motion. It is proposed that this random motion arising from the absorption of the vacuum energy contributes to infinitesimal increase in the rest mass which results in the increase in entropy right at the level of the elementary particle. He calls the process by which the particles absorb energy from vacuum "the vean process". He proposes that this increase in entropy at the level of the structure of the elementary particles results in time acquiring its progressive nature. With this interpretation of the progressive nature of time, the problem of the collapse of wave function gets resolved without invoking the presence of a conscious observer. Even the process of entanglement appears to have space-time limitations. He suggests that the existence of gravitational field and expansion of the universe may be direct outcome of the proposed vean process.

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Key Words : Arrow of Time, Nature of the Progressive Time, Collapse of Wave Function, Entanglement, Vean Process.

1 Introduction

It was earlier shown that a particle has the inner structure of a confined helical wave (CH wave) which is formed by the confinement of a plane polarized electromagnetic waves after it acquires half spin from its interactions with the vacuum fluctuations. The properties of a particle like mass, electric charge and spin were found to emerge from this confinement [1],[2][3],[4]. It was further shown that the states occupied by the CH wave successively in time by its interactions with the vacuum fluctuations form a gas called the primary eigen gas. The only difference between the primary eigen gas and the real gas is that while in the real gas the microstates are occupied simultaneously, in the case of the primary eigen gas the micro-states are occupied successively in time. In spite of this difference, we can derive the thermodynamic relations of the primary eigen gas based on statistical mechanics [5]. It was observed that while the primary eigen gas approach treats time as real, the wave representation of a particle treats time as imaginary. However, it is observed that these two approaches represent the same reality from different perspectives. It has been brought out that the equivalence of these two approaches turns out to be a direct result of a new symmetry called the Wick symmetry. 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 [6],[7]. The basic postulates of quantum mechanics are found to be compatible with the primary eigen gas representation of a particle. However, in the non-relativistic range, the primary eigen gas is found to satisfy the classical diffusion equation which can be obtained by carrying out Wick's operation on the Schrodinger equation.

We saw that the primary eigen gas approach treats time as real and reversible while the quantum mechanical approach treats time as imaginary. We observed that the concept of the imaginary time has to be used when a micro-system is assumed to occupy more than one state at an instant. In other words, the use of imaginary time means that the micro-system is occupying a number of states at the same instant in a virtual or unreal manner. This is why we are able to represent a particle as a wave front as the particle could occupy all points on the wave front in a virtual manner. On the other hand, in the primary eigen gas approach, we treat time as real and reversible. Here the primary eigen gas is assumed to evolve along one path at a time and jump back in time to the original point and again jump forward along a different path. This way, in the reversible time also all points on the wave front could be occupied at the same instant. But this treatment focuses on a single path of progression at a time and hence time has to be treated as real, but reversible. In both these approaches time possesses the directional symmetry. This means that the system exists in an unmanifested state where it may evolve as much in the forward direction in time as it may in the reverse direction. In simple terms one can say that, time behaves like space, as particles may evolve in either direction.

In both the cases discussed above, the entropy of the system remains constant. Remember we are dealing with a free particle. Therefore, the reversible time of the primary eigen gas and the imaginary time of quantum mechanics are quite different from the progressive time with which we are familiar in our day to day life. In the progressive time, entropy is not an invariant quantity. It increases with time. In fact, in the progressive time, the concept of reverse time-travel is absolutely unthinkable. It seems that when we move from micro-systems to macroscopic bodies, time somehow seems to lose its reversibility and starts exhibiting its progressive nature. We do not know if there is some basic interaction which is introducing this irreversibility to time at the macro-level. We shall now investigate this aspect in depth.

2 Vacuum Energy Absorption (vean) Process and the Progressive Time

We know that the progressive time as we perceive it macroscopically is marked by a commensurate increase in entropy. In fact, it is reasonable to use increase in entropy as a marker to measure the progression in time. Considering the fact that in the case of the imaginary time and reversible time, entropy remains constant, one is compelled to take it as the most basic property which determines the progression of time. Ultimately, the veracity of this assumption has to be tested against the prediction we can make based on it.

Once having agreed to treat entropy as a marker to measure the progression of time, the next question that comes to our mind is regarding the level at which the random motion that generates it exists. To begin with let us take the random motion at the level of the molecules, as a macroscopic system is basically constituted by an array of them. We know that this will not make sense because in that case, the rate of progression of time will become a function of the temperature of the body which sounds quite ridiculous. Besides, we know that the rate at which some of the fundamental particles decays follow a fixed time scale. Therefore it is reasonable to assume that the progression of time occurs at the level of the structure of the elementary particle itself. The increase in the entropy which may be used to reckon the progression of time may have to be done at this level. The fact that in the primary eigen gas approach the rest mass of a particle can be treated as its sub-quantum heat content means that it can be attributed a definite value of entropy also. In other words, the progressive nature of time may be attributed to the interactions with the vacuum fluctuations which create the CH waves themselves.

We saw that in the reversible time and the imaginary time, the entropy of a particle remains invariant. We also saw that the action-entropy equivalence expressed by equation

$$-A/h \quad = \quad S/K \tag{1}$$

leads us to conclude that the least action principle of mechanics and the second law of thermodynamics represent the same reality for a micro-system. Here it is worthwhile to recall the results we obtained earlier [5] where it was found that the rest mass of a particle could be identified with its internal heat. We know that in the equilibrium situation $E_o = K\theta_o$ where E_o stands for the rest energy of the particle while θ_o represents the temperature of the primary eigen gas representing the particle. Of course $K\theta_o$ represents the average energy of the interaction of the vacuum fluctuations with the particle. Remember that the CH wave representing a particle has got two degrees of freedom and for each degree the energy of interaction is equal to $\frac{1}{2}K\theta_o$. This means that E_o/θ_o, which is the intrinsic entropy, will remain a constant. If we take another particle having rest mass, E_o' then also the intrinsic entropy E_o'/θ_o' will remain the same. We may express this by the relation

$$E_o/\theta_o \quad = \quad E'/\theta_o' \quad = \quad K \tag{2}$$

This means that absorption of sub-quantum heat by a particle would not result in the increase in its intrinsic entropy.

But when we take the extensive entropy of the system, the situation is different. Here the number of primary eigen gas states n plays an important role. We know [5] that if we take two primary eigen gases which exist side by side, then

$$nNT_o \quad = \quad t_o \quad = \quad n'NT_o' \tag{3}$$

where T_o' represents the intrinsic time of another primary eigen gas with different rest energy, while N denotes the number of micro-states constituting the primary eigen gas (this is taken as a constant) and n, the number of primary eigen gas states which are occupied successively. Since $T_o = h/K\theta_o$, we have

$$n/\theta_o \quad = \quad n'/\theta_o' \quad or \quad n/E_o = \quad n'/E_o' \tag{4}$$

If the rest energy of the particle $E_o' > E_o$, then $n' > n$. This shows that the number of primary eigen gas states that exist in a given duration will be more for particles having higher rest mass. Although the intrinsic entropy $\hat{s}$ of these two particles are the same ($\hat{s} = K$), it is obvious that their extensive entropy

$$S^{\#'} > S^{\#} \tag{5}$$

where $S^{\#'} = n'N\,\mathrm{K},\ S^{\#} = nN\,\mathrm{K}$. Therefore, we can say that if we take two primary eigen gases representing two particles, then, the extensive entropy of the gas with higher rest energy will be higher.

In (5) we now have a very interesting way of relating the increase in entropy, and as a result, the progressive time with the structure of a particle. A particle has to absorb infinitesimally small quantum of energy from vacuum during its interactions with the vacuum fluctuations to have positive variation in the extensive aspect of the entropy. This absorption may be taking place during the interactions of the vacuum fluctuations which confines it creating the mass and the charge of a particle. We know that in the case of any interactions involving macroscopic bodies, a small portion of the kinetic energy involved is used to set up oscillations within its structure. This results in the conversion of a small portion of mechanical energy into heat energy. We may imagine that something similar may be occurring in the case of the interactions of a particle with the vacuum fluctuations also. We know that [4] the interactions with the vacuum fluctuations could be dealt with just like any other interactions. Here also part of the energy could leak out as heat. The only difference may be that the portion of energy converted to the internal heat may be infinitesimally small portion of the energy of the vacuum fluctuations. This can be attributed to the fact that the only motion available for the particle to store up this energy is the random translational motion or the jiggling motion. Note that this jiggling motion results in infinitesimal increase in the kinetic energy of the particle while its rest mass remains unchanged. Strictly speaking this is not correct. Later we shall show that even the jiggling motion contributes to the rest mass of the particle. We shall ignore it for the present. This jiggling motion basically increases the heat content of a macroscopic system which in turn increases its entropy. If we take a macroscopic body constituted by trillions upon trillions of such particles, this increase in the kinetic energy would result in the increase in the heat content of the macroscopic body which in turn results in the increase in its rest mass.

We may call this the vacuum energy absorption process or the "vean process" to be short. In the light of the above discussion, we can state that when the primary eigen gas absorbs an infinitesimal portion of energy from vacuum, the entropy increases infinitesimally. Since the progressive time is marked by an increase in entropy, this absorption of the infinitesimal energy from vacuum may be the interaction that generates the progressive time. The only problem we have here is that in such a situation, vacuum will not remain a null state. It will act as a source of energy. Of course, the energy absorbed by the particles will be so small that even over long duration of time vacuum could be treated as a null state. For an individual elementary particle the energy absorbed from vacuum may be observable only over cosmological time scale. However, for a massive body such absorption of energy from vacuum should result in a force field around it. We shall show in a separate paper that the concept of the vean process is implicit in the general theory of relativity.

The energy absorbed by a particle during a given period under the vean process will be very small that for all practical purposes one may ignore it. Therefore, the particle can be assumed to exist in the imaginary or reversible time where reality does not get crystallized. However, if we take a massive body constituted by a very large number of such particles, then we know that the kinetic energy due to the jiggling motion of the particles also will contribute to the rest energy of the massive body. Since mass can be taken as the heat content, the vean process would result in the increase in the mass of the macroscopic body.

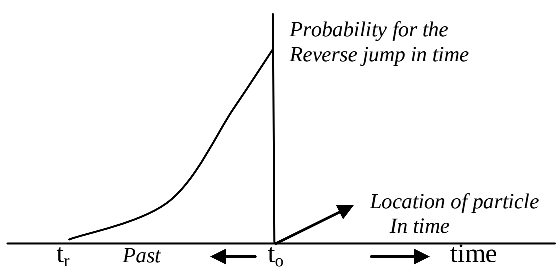
3 More on the origin of the progressive time

Before we proceed further with the concept of the progressive time we have to familiarize with the basic concept of time in the primary eigen gas approach. We saw that the evolution of time in a particle is determined by the progression of N [6]. We also know that as the value of N increases by unity, the corresponding plane wave representing the particle progresses by one wavelet. In other words, when N increases by unity, the intrinsic time of the particle increases by one period of the plane wave. Note that here the increase in N is mediated by the absorption and emission of momentum by the particle from the vacuum fluctuations. The particle need not exchange energy in the process. The confinement of the CH wave involves perfect reflection and we know that when the helical wave gets reflected, there is no change in its energy. Only its momentum gets altered. In the reversible time, a particle jumps from N = 0 to N = 1 and back and forth thereby occupying all possible states [7]. In other words, the particle evolves along all possible paths.

Let us now take the case where the interactions take place with the number of micro-states N taking decreasing values. Note that when N takes decreasing values it can be represented by negative numbers which increases in the negative direction. This means that nN also can take negative values where n denotes the number primary eigen gas states. Since our experience is confined to the progressive time, it is difficult for us to imagine a situation where nN decreases. But in the reversible time it is equally possible. This means that while the momentum exchange interaction with vacuum increases the values for nN along the positive direction, it could also occupy states such that nN moves in the negative direction. Note that in the reversible time and the imaginary time the positive and the negative energy states of the particle exist side by side. The only difference between the reversible time and the imaginary time is that in the imaginary time the particle is assumed to evolve along all possible paths simultaneously with the negative states following them as a shadow while in the case of the reversible time the particle is assumed to evolve along one path at a time then jump back and evolve along another path. In this manner all possible paths of evolution are occupied. This means both approaches are presenting the same picture, only the perspectives are different. It is obvious that in the reversible and the imaginary time all possible paths of evolution for the particle exist as a block. This may be the world Everett imagined [8]. Here, so long as there is no continuous absorption of energy from vacuum, time will not progress and will retain its directional (forward and reverse) symmetry.

We know that in the process of confinement, the CH wave undergoes jiggling motion as the energy and the momentum of the reflected wave will not be exactly equal to that of the forward wave [4]. Of course over a large number of interactions they may even out as vacuum acts like a null background for all practical purposes (here we are ignoring the influence of the vean process). We should keep in mind that while absorbing energy under the vean process the particle does not get crystallized in a particular eigen state. The reason for this is that the quantum of energy absorbed under the vean process is so small that it will get camouflaged under the fluctuations in the energy of the particle due to its interactions with the vacuum fluctuations. It will require a large number of absorptions under the vean process before the particle reaches a stage when it will no more be camouflaged under the vacuum fluctuations. In such a situation, the absorption of the vean energy becomes perceptible and the particle may be treated as a crystallized state which will no more be able to jump back in time. This is an important point to be kept in mind.

As the quantum of the vean energy absorbed by the particle accumulates, it will become impossible for the particle to go back into the past beyond a certain limit (figure 1). This limit is determined by the average fluctuation that occurs in the rest energy of the particle. Note that this will drastically reduce the probability for a longer jump back in time. Here we should keep in mind that in quantum field theory, the fluctuations in the rest energy of a particle is taken to be zero as it is assumed to be sharply defined. Therefore, when we talk about the fluctuations in the rest energy of a particle, it should be understood that we are talking in comparison with the infinitesimally small amount of energy absorbed under the vean process in a small duration. There is no contradiction here with regard to the approach followed in quantum field theory. Thus we see that the fluctuations in the rest energy of the particle set the limit for the reverse jump of the particle in time. While a single quantum absorbed under the vean process does not catch the particle in one eigen state, it pushes the particle forward in time limiting the



The curve represents the probability of the reverse jumps in time. Longer the time interval, lower will be the probability for the reverse jump. In the figure the particle is at t_o and it can undergo reverse jump to any point on the time axis between t_o and t_r. But a jump to any point t where $t < t_r$ is impossible.

Figure.1

duration in which it can carry out its reverse jump in time. Here we have to keep in mind that the system may also jump into the future and jump back. But there is no limit to such forward jumps in time unlike in the case of the reverse jumps. The vean process introduces this asymmetry between the reverse and forward jumps in time.

Now we shall examine what happens in the case of a macroscopic body. Here the number of particles involved is very large and since the fluctuations take place randomly, the positive and negative fluctuations in energy will cancel each other out almost absolutely. At the same time the total energy absorbed under the vean process for the macroscopic body will become substantial due to the large number of particles involved. This means that for a macroscopic body the fluctuations in their rest energy are not available to camouflage the increase in its rest energy. In other words, the macroscopic body will not be able to jump back in time in the manner a microscopic particle could do. In the light of this we can say that a macroscopic system exists in the progressive time where reality is crystallized at every instant. This shows that when we construct a wave function for a macroscopic body, it will make no sense as the wave function represents the state of a system that exists in the imaginary or reversible time. While a particle like electron may get a long time interval in which to exist in a virtual manner, for even a nano-particle, the time interval for the virtual existence may get shortened substantially. We shall show in a separate paper that even for a grain of sand, the time interval in which it could exist in a virtual manner would be in the range of 10^{-22} seconds.

4 Jiggling Motion and its Contribution to the Particle's Mass

We saw that the CH wave undergoes jiggling motion due to its interactions with the vacuum fluctuations. We should keep in mind that the kinetic energy associated with the jiggling motion also will contribute to the rest mass of the particle. We saw this principle in action in the case of a gas under translational motion. There it was observed that the heat content of a gas behaves just like the rest mass of a particle [5]**.** An interesting aspect of this property in the case of the particle is that it needs a large volume to contain a CH wave at rest. This is because, the wave length of the plane wave associated with the CH wave at rest becomes almost infinity. Therefore, to obtain a particle with zero kinetic energy due to the jiggling motion would require a very large (infinite) volume for containment. In other words, to obtain the true mass or the bare mass of a particle bereft of the mass due to the kinetic energy arising out of the jiggling motion, the confining volume for the system has to be very large.

Let us represent such a mass by m. If we now reduce the volume in which the particle is confined, the wave length of the plane wave representing the particle will get reduced with the result that the wave length of the plane wave representing the particle decreases which in turn increases the kinetic energy of the jiggling motion. Let us denote by $\Delta m c^2$ the kinetic energy of the jiggling motion. In that case the total mass of the particle will be given by

$$m' = m_o + \Delta m \tag{6}$$

Note that in quantum field theory, a particle like electron is assumed to have an intrinsic rest mass called the bare mass and the exchange of virtual photons with the vacuum is assumed contribute additional mass which is called radiative correction. Since there is no limit to the energy of the virtual photons exchanged with vacuum, the radiative correction can go to infinity. To avoid the problem of infinity, it became necessary to introduce a cut off for the wave length of the virtual photons at the Compton wave length λ_c. Remember that in quantum field theory an electron is taken as a point particle and the introduction of a cut off at the wave length λ_c is absolutely arbitrary. However, in the primary gas approach this cut off emerges automatically. Note that the energy of the electromagnetic wave which acquires half spin on confinement was taken as E_o and this becomes equal to the rest energy $m_o c^2$. Here the momentum of the vacuum fluctuations has a cut off at h/λ_c as any higher momentum will not be sustainable as it will go against the uncertainty principle [4]. Look at the way the problem of the infinite self energy gets resolved by the introduction of the CH wave structure.

5 The Problem of the Collapse of the Wave Function

As the basic principles of quantum mechanics were developed during the 1920s, it became clear that the state of a microscopic particle represented by the wave function is quite different from the state of a macroscopic body. In the case of a microscopic particle, Heisenberg showed that it is not possible to know its momentum and the spatial location or its energy and the temporal location exactly. The uncertainty in their measurements is given by

$$\Delta \text{þ}\, \Delta x \geq h \qquad or \quad \Delta E \Delta t \geq h \tag{7}$$

He showed that the uncertainty principle emerges from the fact that the wave function representing a microscopic particle allows it to occupy various energy-momentum states simultaneously. This concept of uncertainty is completely alien to classical mechanics where a particle is treated as a point mass whose dynamical variables are taken as fully determined at any point of space and time.

The problem of quantum reality was first tackled by Bohr along with Heisenberg and Pauli. Their interpretation is known by the name Copenhagen Interpretation [9]. According to this interpretation, a quantum particle does not have a well defined energy or momentum state. The state becomes real only on observation. This means the act of observation is very crucial to the crystallization of reality. Further, the classical laws apply only to the statistical averages values of observables measured in experiments set up for this purpose. The classical habit of attributing definite values to energy and momentum of a particle is unwarranted according to the Copenhagen interpretation as the quantum particle exists as a wave occupying all possible states. The act of observation introduces a sudden change in the system when the particulate aspect gets expressed. In fact, the act of observation collapses wave function to one state, and the system crystallizes into reality. The apparatus used for the observation has to be a classical one as the process of observation takes place in a macroscopic system.

Quantum mechanics has been grappling with the issue of the collapse of wave function since its inception. Since the wave function collapses only at the instant of observation it means that if there is no observation, the system would remain in an unmanifested state where all paths of evolution will be possible. Observation is assumed to be the act by which the wave function collapses into a single eigen state (primary eigen gas state) and thereby crystallizes into reality. Therefore, in the absence of observation, the world should remain unreal and would evolve along all possible paths some of which may not even follow the laws of mechanics as we know them. We do not know how to define observation in quantum mechanics. Does observation involve a conscious observer? If the observation is recorded in a photographic plate, would the reality be crystallized at the time of the imprint on the photographic plate or at the time the plate is examined by a conscious observer. Again, we should know what is meant by a conscious observer. Could we attribute consciousness to a fly? In fact, the chain of reasoning takes us to absurd situations. This is the reason why many of the physicists decided to avoid this issue altogether, citing it as a metaphysical problem. Nevertheless there have been a number of attempts to reconcile the problem of the collapse of wave function. We shall discuss some of them here.

The approach initiated by Hugh Everett [8], a student of Wheeler, is one of the most audacious attempts in this direction. According to Everett the wave functions never collapse. Instead, each and every potential outcome embodied in the wave function gets crystallized into reality in separate universes. In this approach called the “Many Worlds Interpretation”, the concept of reality is enlarged by having as many universes as there are states in the wave function. If the wave function says that an electron is at a particular location, then there will always be a universe where the electron is at that location, however small the probability is for that. In innumerably large number of universes, the electron would be in other locations. The sequence of observations that we make from one second to next thus reflects the reality taking place in one of the infinite net work of universes. But the problem with this interpretation is that it is not a complete interpretation. Here we would need another theory to explain why out of the infinite sets available, we select the universe we are in where the laws of classical mechanics are obeyed exactly by the macroscopic bodies.

Another interpretation of the collapse of wave function owes its existence to David Bohm. According to Bohm [10] particles like electrons possess definite position and momentum just as in classical physics. But in keeping with the uncertainty principle these features are hidden from view. For him the uncertainty principle represented the limit on what we could know, but implied nothing about the actual attributes of the particles themselves. Bohm’s approach is not local. He imagined that the wave function of a particle is another separate element of reality, one that exists in addition to the particle itself. The wave here acts like a pilot wave which carries or guides the particle along. According to this approach, changes in wave function in one location are able to immediately influence a particle at a distant location which shows that non-locality is one of its basic features. As the wave function guides the particle, it is quite logical to assume that the particle would be guided to where the value of the wave function is large. According to Bohm there is no separate stage of wave function collapse since, if we measure a particle's position and find it at that location that is truly where it was a moment before the measurement took place.

The Italian physicists Giancarlo Ghirardi, Alberto Rimmi and Tullio Weber have proposed another approach based on modifying Schrödinger's equation in a ingenious way that results in hardly any effect on the evolution of the wave functions for individual particles, but has a drastic impact on quantum evolution when applied to macroscopic objects. According this approach the wave functions are inherently unstable and sooner or later they collapse. For an individual particle the collapse of the wave function occurs randomly and spontaneously. An individual particle may collapse once in a billion years. However, when the wave function of an individual particle collapses, it sets into motion collapse of wave functions of all particles with which it is connected. Since a macroscopic body contains billions upon billion elementary particles, this would mean that the wave function of a macroscopic body will always remain collapsed and therefore there will not be subject to the uncertainty principle.

In recent years the approach which has been proposed by Dieter Zeh based on the phenomenon called de-coherence has attracted wide attention [11]. This approach takes into consideration the fact that the bodies which we experience in our day today experience are formed by particles which are bound to each other by continuous interactions and these interactions could be nudging the wave function of the particle making it lose its coherence. That is to say, the wave representing the particle gets smeared out making it lose its crests and troughs. This de-coherence of the wave function of the particle takes away its ability to cause interference effects. In other words, the particle loses its wave nature and starts behaving like a point particle. This way, the particle nature of the macroscopic bodies co-exists with the wave nature of the micro-particles which constitute it. Here one does not need the process of observation to collapse the wave function of the macroscopic objects. This approach while giving satisfactory explanation does not throw any light into the connection between the collapse of the wave function and the arrow of time.

It is very interesting to hear what Penrose has to say about this aspect. Penrose classifies two processes involved in the quantum measurement as the U process and the R process [12]. The wave function while under the U process evolves in a deterministic manner and follows the Schrödinger equation in a deterministic manner as long as the system is not disturbed by the measuring instruments. The evolution of the wave function can be represented by a unitary matrix and hence the usage of U to represent the process. On the other hand, R represents a process by which the instrument catches the system in one of the eigen states. This process is completely random by nature. Here there is nothing like the Schrödinger equation to define the R process. Penrose feels that there should be some deep connection between the second law of thermodynamics, R process and the quantum-gravity union.

A very interesting view about the collapse of wave function has been brought out by Heinz Pagel in his book "The Cosmic Code"[13]. According to him an observation can be done only by a macroscopic system. An observation involves connecting the state of the quantum particle with the state of a macroscopic system. Therefore, in the act of observation, the state of the quantum particle becomes a part of a macroscopic system. This process is an irreversible one. Note that the Copenhagen interpretation also assumes that the experimental set up used for observation has to be a classical system. In the next section we shall show that our approach coincides with the one proposed by Heinz Pagel. It will be shown that a quantum system and a macroscopic system are qualitatively different in the sense that time has directional symmetry in the first case whereas the arrow of time is well defined in the second case. In an observation a quantum particle which exists in a state having time reversal symmetry suddenly finds itself in a state where the time reversal symmetry does not hold good. It will be shown that the paradox of Schrödinger's act emerges from the mistaken notion that time has the same qualitative properties in both systems.

6 The Vean Process and the Collapse of the Wave Function

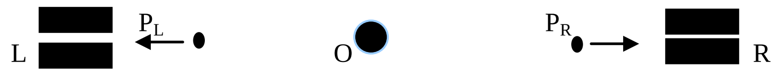
Now we shall try to understand how the primary eigen gas approach deals with the concept of the crystallization of reality. For this purpose, let us examine the state occupied by, say, an oxygen molecule in a laboratory experiment. Suppose that the experiment is set up in such a way that it measures only the momentum of the oxygen molecule as a whole. We know that in such an observation the state of the molecule as a whole will be crystallized without crystallizing the states of the individual atoms constituting the molecule. Each of the atoms will be able to occupy a range of momentum states so long as the total momentum equals to the momentum of the molecular state which is observed. In a similar manner, it is reasonable to assume that the electrons constituting the atoms also may occupy a range of momentum states even when the momentum state of the molecules gets collapsed in an observation. One important aspect which we have to keep in mind is that when the wave function of the atom collapses in an observation, the wave function of any electron belonging to the atom gets focused without getting collapsed. For example, once we observe the state of the atom in a non-ionized state, the probability for the electron to be free is automatically excluded. In other words, the wave function of the electron when the atom is not observed will be different from that which is observed. But the electron can still occupy a range of states which means that its wave function has not collapsed. We may now go one step further and take the case of the 8 protons and 8 neutrons constituting each of the oxygen nuclei. Each of these nucleons in an oxygen atom may also occupy a range of states so long as their total value is compatible with the energy and momentum of the molecule. This layered crystallization of reality is a concept which has not been discussed in the current literature in the collapse of wave function.

We can now analyze the process of the vean crystallization of reality. We saw that the progressive time is determined by the absorption of the vacuum energy by the vean process. For macroscopic systems, the direction of time becomes well defined as there is absorption of finite amount of energy by them in a small time interval. This does not mean that the microscopic particles constituting the macroscopic system exist in the progressive time. Since the vean energy absorbed by a microscopic particle in a finite time interval is much less than the fluctuation in the rest energy undergone by it, time for it retains the reversible property. In other words, the microscopic particle does not crystallize into reality even though the macroscopic system to which it is a constituent crystallizes into reality by virtue of it existing in the progressive time. For a macroscopic body like a speck of dust the vean energy absorbed may be less than the fluctuations in its rest energy only for durations less than 10^{-22} secs. Therefore, that is the time interval in which the grain of sand may be allowed to exist in an uncrystallized state of reality. We see that the vean process does not result in the collapse of the wave function of a micro-system. It only transports the oscillating system forward in real time.

In the proposed primary gas approach, the vean process provides just the required mechanism to focus the evolution of the micro-system along the classical path. We observe that while the micro-system is allowed to evolve along all possible paths, the vean process reduces the freedom of choice for evolution gradually and the classical path becomes the most probable path. For macroscopic systems, the freedom to evolve along alternate paths is completely restricted as already explained. A macroscopic body always exists in the progressive time. In other words, a macroscopic body does not need an observer to collapse its wave function into reality. It always exists in reality and does not need a conscious observer to certify that.

7 The Vean Process and the Issue of the Entanglement

Physicists working in the field of Quantum mechanics were given a wake up call by Einstein when he along with Podolsky and Rosen presented a paper in 1933 regarding certain conceptual problem in physics which is known as the EPR paradox [14]. A more simplified version of the EPR paradox was considered by David Bohm [15] which envisages a pair of



The experimental set up involves emitting of two spin $\frac{1}{2}$ particles P_L and P_R having opposite spin states from a system at O. Two detectors L and R kept at a large distance from each other measures the spin state of the particles at the same instant.

Figure.2

spin $\frac{1}{2}$ particles, say, particle P_L and P_R which start together in a combined spin 0 state, and then travel away from each other to the left and right to detectors L and R at a great distance apart (see figure 2). Here we should keep in mind that the spin state of each of the particles is not fixed till an observation is made. This means that P_L has equal probability of occupying the spin state $+\frac{1}{2}$ and $-\frac{1}{2}$ just as P_R has equal probability of occupying the spin state $-\frac{1}{2}$ and $+\frac{1}{2}$. The uncertainty is there only in the spin state of each particle taken separately. If we take the combined spin state of two particles together, it has to be 0. This property creates a strange phenomenon called the entanglement which we shall discuss now.

Let us suppose that the spin state of P_L is measured at L at a long distance from O which is the starting point of the pair of particles and is found to be $\frac{1}{2}$. In that case, the spin of P_R becomes clearly defined and it has to take up the value $-\frac{1}{2}$. This means that the moment P_L shows up its spin state as $\frac{1}{2}$ at L, some information might have gone from L to R enabling P_R to show up with spin $-\frac{1}{2}$ so that the principle of the conservation of the angular momentum is conserved. If the distance between L and R are large and the measurement at these detectors are done at the same instant, then even a communication at the speed of light may not reach R from L in order to influence the result of the spin measurement at R. This will mean that quantum mechanics has got non-local features embedded in it. An event at one point in the universe may affect another event billions of light years away immediately. This is what is meant by the quantum entanglement.

Penrose says that while the quantum entanglement is a very mysterious property of quantum particles it is surprising that such a ubiquitous phenomenon never shows up in our direct experience of the world. He feels that while the paradox involved in the collapse of wave function has been engaging the great minds in physics, this aspect of the entanglement has not caught their attention as much. He is of the opinion that the U process has to be seen as building up the entangled quantum universe while the R process continuously destroys it. Therefore according to him "Nature herself is continually enacting R-process effects without any deliberate intentions on the part of an experimenter or any intervention by a conscious observer" [16]. We now observe that the U process is the evolution of the micro-system in the imaginary or reversible time while the R process may be identified with the vean process. Note that the vean process does not make the micro-system crystallize into reality instantaneously. In fact, it only directs the U process along the classical path. This means that we do not have to resort to the many world picture proposed by Everett to reconcile the U process by which the micro-systems evolve and the reality of the macro-world which we experience.

We saw that the vean process sets a limit to the region in which entanglements can take place. But this will not apply to the case of photons. For example in figure 3 if two photons of opposite helicity were emitted instead of two electrons of opposite spin, then there will be no space-time limit to the entanglement. This is because the photons have zero rest mass and therefore have zero entropy. Such particles do not undergo the vean process and therefore they always remain in the imaginary or reversible time with no space-time limitation for their entanglements.

8 Conclusion

The concept of the vean process while explaining the increase in the entropy of a macroscopic system and the resulting progression of time also provides us with a process that can explain gravitation. We saw that due to the energy absorbed in the vean process, a massive body will act like a sink for the vacuum energy. This means that there is a net drift of vacuum energy and momentum towards a massive body. Therefore, any mass in the neighborhood of the massive body will experience the flow of vacuum energy and momentum towards the massive body. Note that what happens here is somewhat similar to what happens in the case of the Casimir Effect [17]. There the vacuum energy between the two plates is reduced by the condition only virtual waves that forms standing waves between the plates could exist there. This creates a gradient in the energy field generated by the vacuum fluctuations and this generates a force. In the case of the gravitational field, the gradient is created by the absorption of the vacuum energy by the massive body by the vean process. We shall in a separate paper show how the principle of equivalence and the field equations of general relativity can be derived based on the vean process. One interesting aspect which comes out of this is that the gravitational field is quite different from other fields. While all other fields operate in reversible or imaginary time, gravitation operates in progressive time. This makes gravitational field unique. This also may be the reason why it can not be treated like other fields. We shall later show that the expansion of the universe also can be attributed to the vean process

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