

This is a preliminary draft. I invite your comments, criticism, correction of inaccuracies in statements etc. The last few pages dealing with Eastern Insights do need considerable elaboration and clarification; what I propose to do in the final write-up.

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(B.V. SREEKANTAN)

Draft

Nature of Consciousness

(B.V. Sreekantan)

We all have three distinct kinds of experiences. One is the experience of the external world comprising a variety of animate and inanimate objects and characterized by most fascinating happenings that can be witnessed, and experiences that are shared by others of our kind. The second is the experience of the internal world of thoughts, feelings, emotions, dreams, sleep etc., which is exclusive to each one of us and cannot be directly shared by others. The third is even more personal, the recognition of an individual identity "I" that is innate to the feelings "I saw", "I slept", "I am in pain" etc. - which, as described by some scientists, is what makes me 'me'. All philosophies, oriental and occidental stretching back to thousands of years, and all fundamental sciences going back to hundreds of years, have one objective namely to understand these experiences in a rational way and to arrive at the ultimate reality or realities behind all these experiences.

Let us start with what modern science has to say on these three kinds of experiences. As far as the experiences of the external world are concerned science clearly separates them into two parts. The first part is the physical world "out there" and of which we are a part and which is amenable to a complete analysis in terms of

physics and chemistry. The objects in the external world send out various radiations heat, light, electricity, particles, waves etc., which are sensed by the specially designed sensory organs of the human body. From there on the second part starts and the anatomist and the neuroscientist take over and explain the happenings inside the human body - the conversion of the information brought by the radiations into "action potentials" at the sensory organs, the transmission of the action potentials along the neurons, the discharge of neuro transmitter chemicals at the synapses, the selective roles played by the synapses and the dendrons in further transmission or inhibition of signals to the different cortices in the brain that are specific to particular types of sensations. All these intricate mechanisms have been very thoroughly and elegantly worked out. At the end of the happenings in the neuronal channels what results finally is the release of some very special neuro-transmitter chemicals in the brain cells. The information gets stored as memory for short and long term in the form of some special states of these chemicals. The various parts of the brain are interconnected horizontally with a complicated network of neurons which enables storage and retrieval of information. The retrieval is again through the generation of action potentials and a low level steady gradient of potential created whenever necessary. Some aspects of these mechanisms are, in principle, not different from what happens in a video camera and a video tape recorder. In the video systems the information brought

in as light and sound after passing through sensors and electronic circuits is finally recorded as magnetic elements on the video tape. In the case of the brain the information is recorded as special states of neuro-transmitter chemicals. While this parallelism appears close, in detail however there are lots of problems, in understanding the way in which the brain and the neuro system together operate.

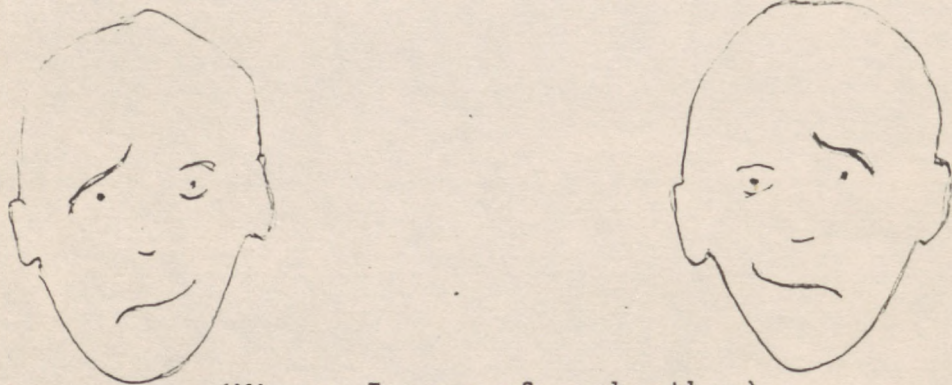
The signals that are received from the outside world in the form of light, heat, sound etc., contain the relevant information in an "analog form". The signals that are sent into the brain through the neuronal channels are digital and most surprisingly the shape and amplitude of the digital signals are the same from all the different sensory organs - eyes, ears, skin, nose etc. A crucial question is, how is this Analog to Digital conversion done at the sensors themselves? Finally at the terminal end the digital information has to be reconverted into analog information. It is claimed that the process is similar to frequency modulation and the information content is in the repetitive frequency of signals and the time separation between the successive trains of the signals. If the brain mechanism has to have any semblance to the electronic recordings and retrieval systems then the information processing in the brain has to be some kind of a real time on-line process also. In electronics systems the only way A-D conversion has been achieved is by using a highly precise oscillator.

The precise mechanism in the sense organs that achieves this very complicated AD and DA conversion is a baffling question still.

Even the most exotic video or audio tapes will serve no purpose other than as storehouses of information unless they are played and the contents seen or heard by a human observer. The mechanisms that have been worked out so far by the neuroscientists, are essentially for the storage of information as states of neuro transmitter chemicals and generation of action potentials in the brain cells. How this translates into the particular experiences, like that of a red rose or a haunting melody or the scary sight of an approaching snake is not at all clear. Clearly the storage of information alone even if it is inside the brain is not enough to answer the question how exactly the information is coordinated and transformed into specific experiences. The mechanism worked out so far may, however, help to some extent in explaining how some of the involuntary functions attributed to the subconscious take place in a manner similar to a machine designed to give specific regulatory orders on the basis of information received. To explain what we call the human experience of the external world, very much more than the storage mechanisms is needed. This is precisely the role attributed to consciousness. Is it something outside the scope of Physics and Chemistry?

In the light of what we have said above, the explanation of the second kind of experiences - that of the internal world of thoughts, emotions etc., becomes even more of a challenge since these are aspects for which there are no counterparts at all in the domain of physical sciences. The neuroscientists have been able to establish with sophisticated recorders like EEG, microelectrodes, tomography etc., that there is evidence for intense physico-chemical interactions taking place in specific regions of the brain when these processes are initiated. Very recently with Positron Emission Tomography it has been found that when a person is asked to think about a certain word, a particular region of the brain shows evidence of increased blood flow due to the release of Ca^{2+} ions in that region. This may be an indication of where the particular word was located when it was first learnt and registered in the memory. It is the general contention that this second kind of experience is intimately linked with "learning process" from the experiences of the first kind and memory storages. A very important finding has been that the left and right brains have different roles to play in the experiences of the second kind. It has been established that in the case of right handed individuals mental aspects like intuition, emotion, response to music, ability to take Holistic look at things and even leaps of imagination are connected somehow with the right brain, while the left brain is responsible for putting things in a sequential order, forming thoughts into words, computations in general and keeping one's life

organised and on schedule. The role of left and right spheres are interchanged in the case of left handed individuals. This finding shows that the experiences of the second kind also do have linkages with specific locations though the exact mechanisms are not clear. The sketches in the figure below interpreted by a right handed person as that of a 'smiling' and a 'frowning' face evoke opposite responses in a left handed persons (the figure is taken from Julian James' book). This shows again the intimate connection between the hemispheres and the nature of 'feelings' evoked.



(Mirror Images of each other)

Yet another interesting correlation between specific locations and recall of old memories was revealed in some of the experiments carried out by Penfield with patients on whom he was doing brain surgery, but who were at the same time conscious. He found that when he touched specific points of the brain with electrodes, ancient memories of songs, lullabies etc that the patient had heard in his childhood days were revived in a highly reproducible manner. The specific details of the incidents recalled and the music associated with those incidents must have been stored

in a wide range of locations in the brain. The exact mechanism by which all the stored information comes into a coordinated sequence when one particular location is excited with a slight electric potential is still to be figured out.

A famous neuro surgeon has said:

"I can dissect and analyse any part of the brain I want to and can do so even in more detail and sophisticated way. Yet it is frustrating to think that however hard I probe, I cannot find where some one's consciousness is or his sense of humour".

In emphasising the type of co-ordinated action that is necessary for a "meaningful" functioning of the brain it has been said:

"An impressionist painting is not composed of impressionist atoms and molecules. It is virtually inconceivable that any one could (even in principle) state the rules stipulating whether a painting was or was not impressionist in terms of the individual molecules". This brings us to the question whether the cybernetic and systems approach is relevant in the context of understanding the functioning of the brain. System theorists have said that the organizational properties of a system are determined by the overall relations among the subcomponents and not on the behaviour of individual parts. It has been demonstrated by neuroscientists that while single cells in a particular brain region respond with great deal of variability in

responding to external stimuli, large assemblies of neurons behave in a much more invariant and predictable fashion and "consciousness" may be viewed as a systemic property of large neuronal assemblies acting in concert. In the systems approach the laws of structures cannot be traced to or deduced from the laws of the constituents which invariably follow the normal laws of Physics and Chemistry.

Is the Brain a Computer?

Since the neuronal outputs are digital and the brain is capable of mathematical computations, and since a considerable amount of co-ordinated exercise is necessary in the functioning of the brain, the possibility that the brain could be operating in a manner similar to a fast digital computer has been considered seriously. One can straight away see certain advantages. The brain has 10^{11} neurons and a thousand time more synapses, compared to 10^9 bits in the best of computers in the world.

Some neurons like the Purkinje cells have as many as 80,000 excitatory synaptic endings. There is a tremendous amount of cross-connections between the different parts of the brain. In terms of 'hardware' there is no question that the brain has the makings of one of the most powerful computers.

According to Marvin Minsky of MIT, "the brain's action is just like that of a Computer. Conscious perception arises as a manifestation of the mere carrying out of

computations". He feels that the next generation computers will be so intelligent that we will be lucky if they keep us around the house as house pets. Herbert Simon of Carnegie Mellon says "we already have machines that can literally think in the same sense as you and I do". Freeman Dyson of Cornell goes one step further in saying "since we now know that mental processes such as Consciousness are purely formal processes, there is an evolutionary advantage to having these formal processes (Consciousness and so on) going on Silicon Chips and Wires, because that kind of stuff is better able to survive the universe that is cooling off organisms like us made of messy biological machinery. So the next stage of evolution will be made out of wires and silicon".

Not all are so enthusiastic about this approach. There are serious problems in thinking of brains as Computers.

No Computer works by itself. It needs a 'software' to direct and control its operation. It is not clear how the software gets generated and fed into the brain. It has to be part of the evolutionary process itself. Unlike in a normal man-made Computer, one encounters with the brain the following problems. The neuronal firings are not deterministic. There is a probabilistic aspect associated with them. It is also known that the same situation does not result in identical pattern of neuronal firings. There is a continuous background firings of neurons and the real

signals have to be transmitted and interpreted in this background. The brain does not have any sophisticated highly accurate timing system that is so essential for computer operations. The firing rates of neurons are slow - something like a $100/sec$ while in the Computers the bit rates go to $10^9/sec$. The interconnections of neuronal networks are known to be random, with lot of redundancy. In the normal computers these connections are regular. Another serious complication is that in the brain due to the all important facility of 'plasticity' the connections are changing all the time. Sometimes old defunct synapses are reactivated. So far no computer has been built with the capability of a changing flexible hardware. In fact, no computer system has been built yet with just organic molecules as the memory and processing units.

Those who are skeptical about the idea of the brain being just a computer remind us that you cannot get semantics (meaning) out of syntax. Some have raised the objection that since we do not know how the brain works, how can we build a machine that can simulate it?

There are also certain anomalies. The cerebrum that has 7×10^{10} neurons is supposed to be "conscious", while the cerebellum with just half that number 3.5×10^{10} neurons, is not conscious but is "unconscious". Why should this be so?

Some have advocated the idea that the brain is a parallel processing computer. This any way is not going to help since even in that case a co-ordination has to be brought about between the different parallel processed data bases to get a 'meaningful' output. There is also the idea that the brain is a Quantum Computer. The implications of this we will consider later.

Physics and the External World:

What is our understanding of the thing-in-itself of the external world?

Let us consider the inanimate part which has been the domain of physical sciences. Following the reductionistic approach of explaining the larger in terms of the smaller constituents, the physical scientists first established that everything we see around us is ultimately made out of the 92 elements - hydrogen to uranium either singly or as compounds of each other. It has turned out that this is true of the animate world also. The elements themselves were later found to be made of just three elementary particles - the protons and the neutrons in the nucleus with the electrons orbiting round the nucleus. The difference between one element and another was just in the number of protons and neutrons in the nuclei. More recently in the past few decades it has been discovered that the protons and neutrons themselves are constituted of even more fundamental units called 'Quarks'. The Protons and Neutrons are made of three quarks each. However these are so tightly bound inside the

protons and neutrons that it has not been possible to release them as free particles. It has also turned out that there exists in nature a host of extremely short lived particles living for less than a microsecond which again are combinations of these quarks and these particles though produced only in extreme situations have an important controlling influence in all that happens in nature in a very subtle and fundamental way.

All the phenomena that we see in nature as part of the inanimate world are explained in terms of the interactions of these fundamental particles under the influence of four basic forces - the gravitational force, the electromagnetic force, the weak force and the strong force. The explanation also requires concepts like space, time, mass, velocity, acceleration and electric charge. These concepts to a great extent evolved out of our own daily experiences and out of "common sense". The characteristics of the four forces are very different and it is now well recognised that it is this difference that is responsible for the manifestation of the wide variety of phenomena in nature.

Space and Time according to the scientist have quantitative aspects associated with them. They are measured to a great accuracy. All things happen in space and time. The most puzzling aspects are however the following. For some unexplainable reason, we attribute to space three dimensions. Why only three? Why not more? Is reality is in more than 3-dimensions of space and we see the

projections of this reality in 3-dimensions? Plato's men inside the cave could see the outside reality as projections in two dimensions only. Time is even more intriguing. We all experience the flow of time in only one direction, from past to future. Why should not time have more dimensions? With the advent of relativity, something very radical happened regarding Space and Time. First of all it was recognised that there was nothing like absolute space and absolute time. The values of spatial intervals and time intervals depended on the frames of reference from which they were measured. A microsecond interval in one frame of reference could be stretched even to a millisecond in another, if the first frame of reference was moving with a very high velocity with respect to the latter. It became necessary to fuse the three dimensions of space with one dimension of time into what has come to be known as Space-Time Continuum. So according to Physics, all physical phenomena are happening in this four dimension space-time continuum. We are not able to perceive them as such. We can only understand and appreciate when these happenings are seen as three dimensional Spatial Projections and undimensional time. What is it in the brain that enables projection of reality in this particular mode?

The situation regarding Space-Time has become even more complicated in recent times. The so called "String Theories" which claim to be Theory of Everything (TOE) require not just a 4 dimensional space-time, but one of 10

dimensions. The theorists are engaged in working out methods of compactification of the 6 extra dimensions into negligible sizes so that they cannot be discerned even with experiments at the highest energy accelerators. It is interesting to point out that the accelerators enable scientists to probe space to 10^{-16} cm and time intervals down to 10^{-23} second. The six additional dimensions of TOE have to be made smaller than these. The reason for highlighting these intricate aspects is to point out that what appear to be the most obvious and straight forward requirements for physical explanation, space and time have themselves become extremely complex. It is remarkable that human consciousness is endowed with the power of discerning a rational causal explanation for most phenomena out of this complicated reality, through a resolution into happenings in a 3 dimensional space and one dimensional time.

Fundamental Particles and their relation to Space and Time:

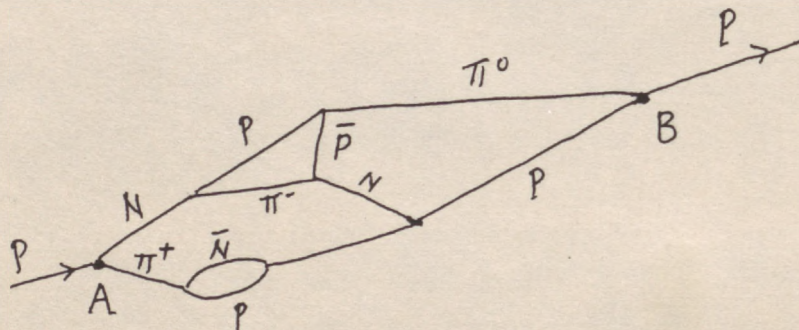
We have seen above that according to current ideas of physics, all phenomena atleast in the inanimate part of the world are due to the fundamental particles called fermions and their mutual interactions. The interactions are brought about by the exchange of another set of fundamental particles called the bosons. For example the gravitational interaction between massive particles is due to the exchange of bosons called the gravitons. The electrical force between charged particles is due to the exchange of photons, the nuclear forces between the quarks

are due to exchange of gluons and so on. Where are these particles and how do they arise and disappear? The clue came from the Dirac's theory of the electron, which led to the postulation of anti particles, which were later discovered in nature. The electron a negatively charged particle has a counter part the 'positron' which is positively charged otherwise identical in mass, spin etc. Similarly the proton has its counter part the antiproton, the neutron has an anti-neutron etc. It was found that whenever particles were created spontaneously or through high energy collisions, particles and antiparticles were created together as pairs. While in nature, the stable particles that we are familiar with, the electrons, the protons and the neutrons can be found in all substances, the antiparticles are just not there. They can only be seen under ~~the~~ special circumstances for extremely short intervals of time. Even when they are produced, they disappear immediately due to annihilation with the particles releasing lot of energy. It has been argued by some that there could be another part of the Universe where just the opposite is the case dominated by anti-particles only where antimatter dominates over matter. There is no concrete evidence yet for this. The most interesting development has been the recognition that all these particles and anti-particles are just states of empty space or vacuum.

In this context, empty space or vacuum assumes an entirely new and different meaning. Vacuum is not the

absence of everything material as was thought, but a repository of all types of fundamental particles in what Dirac called "negative energy states" so that their presence is not normally felt. Whenever there is sufficient amount of energy available either due to "spontaneous fluctuation" or due to an external source as happens in high energy collisions, these particles in the vacuum acquire positive energies and materialise, and can be detected. The spontaneous vacuum fluctuations result in the production of virtual pairs most of the time. The fluctuated energy is not enough to make them real particles, though very occasionally the energy fluctuations do result in the production of real particles. Thus "this something called Nothing" - this empty space - this quantum mechanical vacuum is the basis of "everything". The real nature of things when looked at in extremely short intervals of time could be very different from what is perceived in long stretches of time.

We said previously that the Proton is constituted of three quarks. Combinations of quarks and antiquarks result in the formation of a variety of particles that have been discovered experimentally. The figure below shows how



what appears to be the movement of a proton from point A to point B could really be very different when examined in extremely short intervals of time. This entire play of particles is due to the structure of empty space in terms of the various fundamental particles themselves. It has been recognised that in all physical phenomena involving these fundamental particles per se, quantum mechanical and relativistic effects become supremely important, and the old classical physics ideas of space, time causality undergo drastic changes. In fact Quantum theory removes the possibility of a complete causal account of all phenomena. Determinism is replaced by probability and statistical determinism. Because of the allowed "superposed states", objective reality is not known until an observation is made. Some scientists have maintained that this observation leading to a definite result (technically called the collapse of the wave function) necessarily involves a conscious observer, others think that it would be adequate to have the result of the observation registered by an irreversible thermodynamic system. There is also a third alternative according to which every time a system goes into a superposed state, each one of states is as real as the other, each corresponding to a world in which that particular alternative is the only one and the observer may be in one of these worlds at the time of observation and subsequently until he makes another observation. This "multiple world" interpretation while leading to infinite possibilities is theoretically quite sound and cannot be

ruled out. This approach introduces yet another weird element into the interpretation of physical phenomena in terms of quantum mechanics. According to Bohr "Quantum theory reconciles alternative realities one or the other of which the observer chooses to let happen. It does not reconcile alternative view of reality". According to our classical ideas of causality, anything that happens at a point 'A' is caused by influences in its immediate neighbourhood; causality is essentially local. In quantum mechanics however we come across situations where the results of observation at a point 'A' are determined by the results of observation at a point 'B' which is so far away that information from B cannot travel to point 'A' even with velocity of light which is the limit to all velocities according to the theory of relativity. This particular non-local aspect of quantum mechanics got high-lighted in the efforts to resolve the famous EPR paradox (Einstein - Podalsky - Rosen) by Bell through his Inequality Theroem and the subsequent experiements of Aspect and others. Bell has said "There is a real sense in which particles that have interacted once continue to affect each other long after the interaction has taken place and in an instantaneous way". In this sense, as remarked by Max Delbruck "the Universe behaves like a single organic whole - an intercorrelated absolute - one endlessly diversifying entity". On the one hand according to relativity nothing can travel faster than light. Quantum Mechanics on the other hand admits of non-local causes, requiring instanteneous transmission of

information to far off distances. This continues to remain a dilemma in Physics.

To summarise: Even the explanation of the external world in terms of the fundamental concepts of space, time, elementary particles and their interactions is surfeit with unresolved complexities. However, the general direction in which one is moving is clear. There is only one ultimate reality the quantum mechanical vacuum - the empty space - out of which every thing is created. Every point of space is the repository of all the elementary particles in "negative energy states" which cannot normally be felt or accessed. One of the most important aspects of this space is that it is subject to limitations of the Heisenberg's principle of uncertainty $\Delta E \cdot \Delta t \geq h$. If energy fluctuations take place in extremely short intervals of time, then their magnitude can be large enough to lift particles out of the well of negative energy states leading to the creation of a particle-antiparticle pair. These vacuum fluctuations have been observed in experiments like the "Lamb shift". While the minimum dimensionality of this space-time continuum - the quantum mechanical vacuum, is four it may be as high as 10, if some of the more recent string theories are established. The elementary particles and their antiparticles have very well determined properties like mass, charge, spin, isospin etc. It has not been possible to derive these values on the basis of any theory. Four fundamental forces which determine the interactions of

these particles leading to the diversity of physical phenomena have been identified. These forces arise out of exchange of another set of fundamental particles themselves. There is indication that these forces at extremely short distances are identical, but at larger distances they behave very differently.

In the Big Bang theory of creation of the Universe, the sequential scenario that has been worked out on the basis of all these ideas of space-time, particles is as follows: An explosion - a wide fluctuation - led to the creation of a multidimensional expanding space (this was also the beginning of time.) A variety of fundamental particles got created as the 'hot' expanding space cooled. Out of the particles others were created and finally atoms and molecules of hydrogen - later the other light elements and so on. In the present context, the most important conclusions are that Everything is Space-time Continuum and it is "fluctuation" that is responsible for all creation and subsequent activity.

Mathematics and Nature:

All this progress of physical science became possible with (a) the experimental approach and (b) mathematical formulation of the theoretical ideas leading to predictions and verification by further experiments.

The difference between Physics and Mathematics has been that in physics the theories have to be validated by experiments with nature. If they contradict the observations then the

theories have to be given up. Mathematics on the other hand is validated by its own logic, and is the creation of the human mind. One does not go to nature for its validation. Why then should nature obey the mathematical formulations of the theoretical physicist? What is the connection between nature and mathematics? The reason why we are concerned with this question here is that mathematical activity comes under the category of the experiences of the second kind (Phenomena of the internal world), while the phenomena we are dealing with are of the first kind - phenomena of the external world. According to Heisenberg the decisive beginning of the mathematical science of nature was in the Platonic philosophy. Plato adopted the ideas of Leucippus and Democritus of the smallest units of matter - the foundation of all existence. Plato's atoms were not strictly material but were 'geometrical forms' - these "forms" according to Plato were in some sense the "Ideas" underlying the structure of matter. The cube in Plato's theory for example was the smallest particle of the element earth and symbolized the stability of the earth. The tetrahedron represented fire and the icosahedron, close to a sphere, represented water and its mobility. Heisenberg also points out that among all the possible forms of "understanding" the one that is practiced in mathematics as the "true understanding" because it is precise, a logically consistent language is employed and is capable of proof. Surveying the developments in the field of elementary particles, Heisenberg comes to the conclusion "I think that

on this point (Democritus or Plato?) modern physics has definitely decided for Plato; the smallest units of matter are in fact not physical objects in the ordinary sense of the word; they are forms, structures or in Plato's sense - "ideas" which can be unambiguously spoken of only in the language of mathematics. Democritus and Plato both had hoped that in the smallest units of matter they would be approaching the "one", the unitary principle that governs the course of the world. Plato was convinced that this principle can be expressed and understood in mathematical form. The Central problem of theoretical physics now-a-days is the mathematical formulation of the natural laws underlying the behaviour of elementary particles. From the experimental situation we infer that a satisfactory theory of elementary particles must at the same time be a theory of physics in general and hence of every thing belonging to this physics". Thus what really has brought about a "true understanding" in physics is the use of mathematics.

Emergent Properties:

It has been found that certain properties are not there in the individual constituents, but become apparent in aggregates. A good example is the property of 'wetness' of water. There is nothing corresponding to 'wetness' in individual molecules of oxygen and hydrogen. It is also not there in the vapour form. "Wetness" becomes apparent only in the liquid or solid state of water. At an even more fundamental level the physicists talk of what are known as

"Co-operative" phenomena. Superconductivity is an example of co-operative phenomenon. Here pairs of electrons behave in a low temperature conductor as if they are tied together though they are spatially separated and have distinct identities. This kind of pairing is essentially a quantum mechanical effect. In recent years macroscopic quantum mechanical effects are becoming increasingly apparent. The SQUIDS (Superconducting Quantum Interference Devices) have been in use for measurement of very low magnetic fields for more than a quarter century. What is recent and interesting is that the Squid can be made to exist in a superposed state resulting in distinct macroscopic magnetic flux changes in the associated magnetic field surrounding the superconducting ring.

There is also another phenomenon in physics that will be of particular interest in our discussion on Consciousness later. This phenomenon is known as Bose condensation. It has been found that the behaviour of large assemblies of particles with half - integral spin values (like electrons, protons, neutrons etc.) is different from those of integral spin (like photons, mesons, gluons etc). The half-integral spin particles (Fermions) obey what is known as the 'Fermi - Dirac Statistics' and the integral Spin particles (Bosons) obey the Bose-Einstein Statistics.

While no two fermions can exist in the same state (defined by location, momentum, energy etc.,) the Bosons can crowd into the same state. In a closed system, the

population of the different energy states into which the Bosons crowd is described by the Planck distribution. According to this distribution the lowest energy level will have the highest concentration and crowding. Thus as one cools to lower and lower temperatures one will achieve what is known as the "Bose Condensate" - resulting in a large population in the lowest energy state. It has been shown by Frolich that Bose condensed states can be created not necessarily by cooling, but by "pumping energy" and making use of the "normal modes" of vibrations of a system. A Coherent state with phase and amplitude correlations can be established even over a wide distance range. Such a Bose condensate system can act as an amplifier of signals. A weak signal could trigger such a system and produce a very powerful co-ordinated output. The laser is such a system.

Physics of the Functioning of the Brain:

We have seen that the neuro-scientists have generally treated the entire system of the sensory organs the neuronal channels, the synapses and the corteces of the brain as operating essentially according to laws of classical physics. It is clear from some of the recent developments in physics as summarised in the previous section, there is considerable advantage in treating the system as a quantum mechanical system, since this opens up the possibilities of "superposed states", "non-local causes", "coherent operational modes over wide ranges" within the brain and the associated feeder systems,

"spontaneous creation" subject to "Heisenberg's principle of uncertainty" etc., When even a simple flame of a candle operates according to quantum mechanics, why should such a complicated system as the brain be just a classical system, especially when one of the specific requirements of the brain is to operate in a coherent fashion putting together information that is stored and processed in widely different locations? Evidence for quantum effects in biological systems in general is growing. It has been found that the rate of growth of yeast cells is influenced by exposure to microwave radiation. There cannot be significant temperature changes of the cells by the microwaves unless there is a resonance reaction which is precisely what is observed. There is also evidence for Raman scattering in living cells. Both these require cooperative processes of the type we have discussed above, which are quantum mechanical in nature. Marshall has argued that Bose-condensed states might be the basis of the Unity of Consciousness - the holistic and collective character of the Bose - condensed states are particularly suitable in exploiting this aspect of consciousness. Mechanisms for the creation of such states in biological systems have been pointed out by Frolich. It has been shown by Marshall that even the action of anaesthetics is explainable in terms of the impairment of certain cells to participate in the molecular dipole oscillations that sustain the collective

oscillatory states which constitute consciousness. Eccles in a recent paper in the Proceedings of the National Academy of Sciences (1992) points out the following instance: Radio Xenon mapping and PET techniques show increased blood flow in a localized region of the Neocortex when the person under observation is demanded to generate words. This increased blood flow is attributed to exocytosis - a presynaptic impulse propagating into a bouton and causing an influx of Ca^{2+} ions. However this exocytosis is not generated on every occasion, but with probability of 1 in 3, 1 in 4 etc. and never more than one exocytosis happens. Eccles and Beck attribute this controlling effect to the vesicles being embedded in a paracrystalline vesicular grid that is subject to Quantum physics.

Penrose in his book Emperor's New Mind says "Quantum mechanics involves many highly intriguing and mysterious kinds of behaviour. Not the least of these are the Quantum Correlations which can occur over widely separated distances. It seems to me to be a definite possibility that such things could be playing an operative role over large regions of brain. Might there be any relation between a "state of awareness" and a highly coherent quantum state in the brain? Is the 'oneness' or 'globality' that seems to be a feature of consciousness connected with this? It is somewhat tempting to believe so".

Philosophical approaches: (Seen in the light of modern physics)

Basically there are two types of philosophies. The Materialist philosophies according to which everything including the mind is some form of matter and all phenomena are due to the interactions of the material constituents. and the Idealistic philosophies according to which everything is mental. Descartes went to the extent of saying that the mind stuff is different from the stuff of which ordinary matter is made and proposed somekind of a dualistic philosophy without explaining what the mind stuff was and how it interacted with matter. There are many different shades of monistic and dualistic philosophies. Looked at from the point of view of modern physics and the current ideas of the ultimate constituents of matter - the fundamental particles which themselves are special states of the all pervasive quantum mechanical vaccum, it is superfluous to distinguish between matter stuff and mind stuff. In as much as the difference in the properties of different substances and the variety of physical phenomena have to be explained on the basis of the fundamental constituents and their interactions, it should in principle, be possible to have similar approach to the case of mental phenomena too. We have seen that in order to explain unusual types of physical phenomena like superconductivity, new types of interactions involving coherence over wide spatio-temporal ranges had to be invoked. Quantum tunneling to explain radioactive emission is another case in point.

It is interesting that in these types of explanations, mathematical formulations have been of much greater help than physical insights. In most of these cases we have to give up the idea of physical picturisation, and normal ideas of causality, space and time sequencing.

The new view point that modern physics brings forth in dealing with physical realities is best illustrated by considering the following example of the simplest of all atoms the hydrogen atom. The hydrogen atom consists of the two fundamental particles the proton and the electron. The electron goes round in a fixed orbit around the proton, under the influence of the Coulomb force. To explain the stability of the hydrogen atom, Bohr had to make the assumption that though the electron should normally radiate away its energy when changing its direction continuously, it does not do so in the particular orbit and radiation takes place only when it jumps from a higher allowed orbit to a lower one. For a long time the focus of attention in dealing with the hydrogen atom was on the two particles the proton and the electron. Later on it became clear that there is another important constituent that holds the key to coulomb interaction itself between the proton and the electron namely the properties of the "empty space" between the two. The virtual photons responsible for the coulomb force are generated in this vacuum and propagate in this vacuum. The importance of the polarization of this vacuum by the spontaneous creation of electron - positron

pairs and their influence on the strength of the coulomb force was shown by the famous Lamb Shift experiment.

We should also not forget that in the ultimate analysis the proton and the electron themselves are states of this vacuum. Thus what was ignored or taken for granted namely the empty space takes on the most dominant role. Even the most complicated phenomena observed in nature will have to find an explanation in terms of this quantum mechanical vacuum. Even life and consciousness should be manifestations of complicated activities of this underlying reality, which from the point of view of the physicist has a profound mathematical content associated with it. Such an approach resolves automatically the mind body problems.

The physical sciences are leading us to the conclusion that everything around us is a manifestation of empty space - the quantum mechanical vacuum. It is the "fluctuation" of this empty space that is responsible for all creation including space, time, matter, radiation etc which in turn are responsible for all the phenomena that we see around us. The attempts to reduce the phenomena of the animate world - life, mind, consciousness - also to special states of matter will mean that even these are manifestations of the same ultimate constituent namely empty space. A fluctuation of some indescribable kind resulted in the creation of expanding space and time and all else resulted from further fluctuations. These include all matter and

radiation and the mediators of all types of interactions between these which we call the physical forces. The character of the quantum mechanical vacuum and its evolution is however defined by mathematical equations. A puzzling aspect that remains is this particular role of mathematics, which is a creation of the human mind and which came into existence much later in the evolutionary sequence. A way out may be the "Platonic world" of mathematical entities which may have preceded the emergence of the physical world and its evolution.

Eastern Insights: Advaita and Sunyata

Let us examine how some of the eastern thinkers have analysed these very same problems relating to the ultimate reality that is behind the physical and mental worlds, and what their views are on Consciousness.

According to the Advaita philosophy propounded by Shankara based on the Vedantha philosophy, there is only one ultimate reality that is Pure Consciousness, which is also called Brahman, and everything else space, time, matter, life, mind etc., are all manifestations of this pure consciousness. How does Shankara come to this conclusion?

First of all he treats all the three states - the waking, dreaming and deep sleep states which are in the experience of every one - on the same footing. What is common to the three states is the Experiencer, while the experiences and the experienced are different. It is this

experiencer, the Avastha Traya Sakshi (the self) which Shankara identifies with pure consciousness. In the waking state there is the experience of space, flow of time, and the entire phenomenal world of matter and radiation. In the dreaming state, while similar kind of experiences of space, time, matter are there, the spatial configurations, the rate of flow of time are quite different. What is a few minutes according to the waking state could be a whole lifetime in the dreaming state. In the deep sleep state, there is neither the experience of flow of time, nor any spatial configuration nor any matter and radiation. But clearly there is the experience of the absence of all these. Without this experience one would not be able to make statement like "I slept nicely". This pure state without any adjectives that one glimpses in deep sleep is identified as the state of pure consciousness in which the subject-object relationship is completely merged and is taken as the ultimate reality from which, through a process of transformation or superposition, everything else that we see in the other two states emerge. Shankara points out that the claim that reality can be comprehended by a study of the waking world only is a mistake of shadow for substance. Intuitions of sleep and dreams are necessary for a full understanding of the ultimate reality. The Vedantin does not agree that sleep is just a temporary inactivity of the brain and sensory organs and that dream a partial fantastical disturbance of the nervous system. While the knowledge of the external world comes through perception in

the waking state, sleep and dream need intuition. Our organs of perception are not suited for the study of the states of sleep and dream. It is the "self" (consciousness) that sees, hears, thinks, resolves, enjoys, and is beyond the senses and mind.

To summarise: You and I and the entire world are a manifestation of Pure Consciousness. It is recognised as Pure Consciousness in deep sleep and as ego and non-ego in the rest. Pure Consciousness itself is not divided since space, time necessary for division are only in the sphere of manifestation. If we want to study Pure Consciousness objectively we have to study the world spread out before us. Pure Consciousness regarded as Sleep is in truth entire reality. The world is "kinetic" aspect of pure Consciousness. (This pure Consciousness was for Berkeley the Universal mind, for Kant the thing-in-itself, for Spinoza - the substance, for Fichte the Universal ego, for Bradley the Absolute, to Hegel the self-determined Self-Consciousness to Bergeson - wider consciousness and change). The exact process by which this transformation or manifestation of pure Consciousness takes place to give rise to the phenomenal world cannot be described in terms of the processes we are familiar with since the latter including space, time, matter are the result of the former. This indescribable process is termed as 'Maya',. Suffice to state at this juncture that Maya is that which is responsible for the transformations. [In my view this

situation is not different from what the Physicist has to say when a creation takes place as due to Fluctuation. Fluctuation is not a causative force. It just happens, because that is the characteristic of the underlying reality; without this 'fluctuation' there would be no creation no activity].

The "Sunyata" Vada of the Buddhist Nagarjuna is another line of eastern thought that we should consider in this Context.

Nagarjuna, lived in India at the beginning of the Christian era, and was responsible for formulating the Mahayana Doctrine of Buddhism - the so called Madhyamika School. On the basis of what has been recognised as a formidable, ruthless logic he comes to the conclusion: Nothing is real; the world has only a phenomenal existence. It is just an ideal system of qualities and relations in which we believe, but cannot intelligently explain. Yet, behind all this experience he hints the presence of something - the 'Absolute' which is beyond the capacity of our thinking. This 'Absolute' is in Buddhist philosophy 'the Sunyata' or "Nothingness" (Sunya means Zero). This Buddhist concept of Sunyata is very different from common man's concept of vacancy or nothingness. Actually Sunyata is something transcendent and immanent in all things. It is on account of 'Sunyata' that every thing becomes possible and without it, nothing in the world is possible.

The elaboration of this 'Sunyata' by the Dalai Lama is most interesting.

"Emptiness (Sunya) is the basis of everything and is a reflection of everything depending on everything else. It is like Zero. Zero itself is nothing. But we cannot make 10,100,1000, without zero. Because of emptiness things appear and disappear. It is possible to experience this emptiness through meditation - going into subtler dimensions. When all the five sense organs of sight, touch, sound, smell and (ordinary) mind stop, you can reach the subtler inner mind. The ultimate basis of all matter are 'space particles'. The ultimate basis of Consciousness is 'light' - 'energy'. The ultimate Creative Principle is Consciousness. The innermost subtle consciousness is always there".

According to the (Kshanika Vada) Buddhist theory, reality is in a sense "virtual". What appears to be real objects like trees, people, actually are transient illusions which result from limited mode of awareness. The illusion is that things are permanent. 'Enlightenment' is the realisation that things are transient. According to the Flower Garden Sutra "Each part of a physical reality is controlled by all other parts. This is illustrated by the 'Indra net' - a vast network of gems which overhangs the palace of Indra, so arranged that if you look in one you see all others reflected in it. In some sense each object in

the world is not merely itself, but involves every other object and in fact is every thing else.

What advaita has done by identifying Consciousness as the ultimate reality and as the basis for the manifestation of everything that exists and that we experience, is very similar to what modern physics has done in arriving at empty space or quantum mechanical vacuum as the ultimate reality and from which everything else space, time, matter, energy etc have emerged. To be able to explain the physical phenomena in the way that Science has understood, it is necessary to attribute to this empty space certain intrinsic qualities rigorously defined by quantum mechanical equations - the mass states, the energy states, the spin properties of the fundamental particles making up this quantum mechanical vacuum and also attribute specific values to the physical constants. One has to take all these as given and not derivable from any other considerations. Out of these have to emerge all particles, all matter, all forces and all phenomena through fluctuations and interactions with each other.

In advaita philosophy, Consciousness which is the basis of everything is similarly endowed with attributes and characteristics like existence, knowledge, infinity, indivisibility, spontaneity etc (Satyam, Gnanam, Anantham,.....)

In such an approach instead of consciousness being treated as a property of matter, the opposite becomes the case - matter has to evolve out of Consciousness which has its own intrinsic attributes and 'laws' of its own.

The Scientists came to the recognition of the ultimate constituents of matter in what they describe as the quantum mechanical vacuum, through a series of ingenious experiments, theoretical insights, mathematical formulations over the past several hundred years, the most crucial ones being in the current century. The eastern thinkers typified by the two examples we have considered above came to similar conclusions on the nature of ultimate reality much earlier in time, through an analysis of their experiences of every day life and employing powerful logic. Though in details and in their attributes to the ultimate reality Quantum Mechanical Vacuum in the case of the science, pure Consciousness in the case of Vedanta and Sunyata in the case of Buddhist philosophy there are great differences, what is most remarkable is the recognition of 'Unity' in diversity.

It is important to stress that what is normally termed "mysticism" is not at all involved in arriving at the 'advaita' or 'sunyata' theories. It is a well recognised fact that ~~the~~ rare "flashes of genius" have contributed significantly to the advancement of scientific knowledge. such "flashes" cannot be ordered, but do occur and are attributable to special mental states. There are also other transcendental states experim^{enced}ted by many on rare occasions.

What some of the eastern thinkers (also some in the west) point out is that through practices like meditation, yoga etc., it is possible to access these transcendental states and in these higher level states one recognises more easily the unity behind all the diversity. Psychobiology of transcendence has become an important field of investigation in the west and increasingly use is made of the sophisticated instruments like EEG, PET etc., for such studies.

In this context, the following quotations from some of the leading biologists, physicists, may be significant. Von Weizacker: "Consciousness and matter are different (1971) aspects of the same reality".

George Wald : "Consciousness is not part of the Universe of (1979) space and time, of observable and measurable quantities, that is amenable to scientific investigation".

Wolfgang Pauli: "It would be most satisfactory for all if 1952 physics and psycho (i.e matter and mind) could be seen as complementary aspects of the same reality".

Schrodinger : The whole world is a project of one undivided Cosmic Consciousness and each of us is an integral part of it".

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