

Science and Consciousness

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The approach of the life scientists, particularly of the neuroscientists to tackle the problem of Consciousness is spelled out by Francis Crick⁽¹⁾ in his book "The Astonishing Hypothesis" as follows:

"Your joys, your sorrows, your memories and your ambitions, your sense of personal identity, your free-will are all in fact no more than the behaviour of a vast assembly of nerve cells and their associated molecules"

Following this line of investigation, the neuroscientists over the past several decades have been able to make a wonderful job of mapping out in minute and elaborate detail the various locations, contours and layers of the cortices of the brain, the corresponding sensors and the connecting network of neurons running into literally billions. In this endeavour the recently developed tomographic instruments like the CATSCAN, the PET, the fNMR, and also the reflecting laser devices and the microelectrodes all coupled to on-line computers in addition to the EEG and anatomical probings have been of great help. The chemical, physico-chemical, electrical and electronic processes going on in the different branches of the neural network, in the blood streams and in the sensors have been identified. The variety of information received by the sensors like eyes, ears, nose, skin is first converted into electrical pulses and carried to the corresponding layers of the cortices in the brain. While the approach implied in the above method outlined by Crick has facilitated in unearthing and establishing the various channels and locations of the brain activity connected with particular 'events', what has not been possible is to explain how exactly these brain activities give rise to the particular feelings, sensations – joy, pain, happiness etc., or how they trigger memory, thoughts etc, or how inspirations, illuminations arise. These certainly are of a different category of experience and very different from chemicals and electrical pulses, the nerves and the blood streams. While this category difference is confounding the life scientists, the physical scientists, are for

some time now, quite used to connecting entities which in the first instance appear to be widely disparate and totally unconnected. This strange facility has come about as the result of several transcendences that have taken place in the field of physical sciences and to which they have to get accustomed. By transcendence here one means only "outside the limits of normal human experience" and not necessarily anything spiritual. With the remarkable developments in instrumentation – microscopes, telescopes, accelerators, on-line computers etc., the limits of normal experience have also changed with time resulting in modification of ways of thinking and analysing problems. Let me illustrate.

As the scientist started going up the reductionistic ladder stretching from elements to molecules to atoms, to nuclei and to fundamental particles and figured out the forces operating at different levels, he suddenly ended up in an all dominant, all pervasive, substratum called four dimensional space-time continuum, the quantum vacuum, regarded now as the basis of the entire physical world. Reductionism ended in holism!

While the dominant role of this substratum first revealed itself in the happenings of the microworld of elementary particles, it has to be emphasised, that its role is equally dominant in dealing with many macroscopic phenomena. In fact according to the most popular theory of creation of the universe, namely the Big Bang theory, it is the expanding space-time that was created first out of which all the matter and radiation associated with the universe we are familiar with, got created at various stages following the sequence of particle creation, formation of atoms, molecules, stars, planets and finally biological evolution on the planet earth. Right from the time of Newton who formulated the laws of classical dynamics and applied them to explain the laws of planetary motion that had been deduced by Kepler, one important question had remained unanswered – the question of "action at a distance" – how is the gravitational force transmitted between the sun and the earth with such a vast distance between them? Similar questions arose in the case of magnetic forces and electrical forces though the distance scales were orders of magnitude different. Maxwell faced the problem of propagation of electromagnetic

waves and his attempts to account for it in terms of the elastic properties of the "ether" (that had been introduced to explain the so called field properties) failed. Finally it was only in the 20th century that this problem of action at a distance got solved as we shall see, by a radical departure of the concept of "force" itself and also of "space" between the bodies.

In the early days of science, the concepts of space, time, mass, energy, force etc., were all drawn from everyday experience and scientific methodology consisted of suitably redefining them, introducing standard units for each of the quantities to make meaningful measurements, designing suitable experiments to verify or falsify the theories formulated to explain phenomena in the outside world, making use of conservation principles - like conservation of energy, momentum, angular momentum and conservation of mass, all deduced from systematization of observations. An important new feature that had been introduced by Newton was the framing of mathematical equations and solving them. This particular feature revealed the subtle controlling aspect of "natural constants" and their universality. While a large range of phenomena associated with - the properties of matter in the form of solid, liquid and gaseous states, the acoustical phenomena, the electric and magnetic properties of substances, and the phenomena of heat and light got explained and the methodology of science was proving triumphant, towards the end of the 19th century a series of new discoveries resulted in the necessity of overthrowing the then existing 'concepts' of space, time, mass, energy and even causality.

The famous experiment of Michelson and Morley showed that the velocity of light was a constant and independent of motion of the source or the observer. This was totally against normal experience and the theorem of addition of velocities that had been very well established in all mechanical motions. To be able to understand this new feature Einstein introduced the Special Theory of Relativity in which space and time were fused into four dimensional space-time continuum transcending the normal notions of independent three dimensional space and one dimensional uniformly forward moving time. Further elaborations of the theory of relativity resulted in many radical changes in

our way of thinking about the happenings in the external world. Mass and Energy became equivalent through the famous equation $M=Ec^2$ and somehow connected through the velocity of light in vacuum c . The rate of flow of time and the length of space intervals, and the value of mass itself became dependent on the velocity of the frame of reference in which they were measured. The universal character of absolute time and absolute space had to be abandoned. More interestingly the idea of simultaneity had to be given up since an event which was simultaneous in one frame of reference was not so in another. With the introduction of the General Theory of Relativity to account for phenomena associated with accelerated frames of reference, even more drastic departures of concepts from normal experience followed. Space was no longer Euclidean and mass became equivalent to curvature of space and the concept of gravitational force was not required.

Einstein says:

“Matter when we perceive is merely nothing but great concentration of energy in very small regions. We may therefore regard matter as being constituted of space in which the field is extremely intense. -- Field is the only reality”

The years 1896, 97 and 98 are regarded as hat-trick years from the point of science. Three major discoveries of profound significance and consequence were made in these three successive years – discovery of x-rays, of Radioactivity and of the Electron. These discoveries together with the theories of relativity steered the course of science in the 20th Century.

The emission of α -particles by a heavy nucleus like Uranium could not just be explained within the classical framework of Newtonian Dynamics. An α -particle inside the Uranium nucleus did not have the necessary energy to overcome the potential barrier. Still particles were coming out. This was explained on the basis of the quantum mechanical tunnel effect, by writing down the Schrodinger wave Equation and solving it to calculate the probability of the α -particle being in a location outside the nucleus. The α -particle was registered as a particle by a particle detector like a Geiger counter or a

Cloud chamber. However, the same had to be treated as a wave in passing through the potential barrier! Thus compared to the classical way of thinking which would demand a regular trajectory for the α -particle – locating the position of the particle as a function of time at each instant, in the quantum mechanical approach only the probability of finding the particle in a particular location is what is calculated; also in classical physics the same entity cannot be both a wave and a particle. The physicist had no choice but to get accustomed to a complementary aspect of whatever is the reality.

We have talked about the four dimensional space-time continuum as the substratum for all creation. Another aspect of the substratum came into focus with Dirac's effort to develop relativistic quantum mechanics. Dirac's equation for the relativistic electron gave solutions for energy states which were both positive and negative. The normal practice in physics till then, was to treat negative energy solutions as 'unphysical' and to just ignore them. However, Dirac transcended the normal practice and interpreted the negative energy solutions in a bold and ingenious way. He made the assumption that normally all the negative energy states of the electron, an infinite number of them perhaps, were completely filled in vacuum and inaccessible as free particles. However either due to a spontaneous fluctuation or by the deposition of energy, a negative energy electron could be lifted to a positive energy state, a 'hole' would be created in the vacuum filled with all the negative energy electrons and this 'hole' would appear as a positively charged particle and if the energy was sufficient then the 'hole' would have a positive energy too and there would be a pair of particles one negatively charged and the other positively charged. The 'hole' was called the 'positron'. It so happened that Carl Anderson in the US who was unaware of this development in England, discovered around the same time (1932) the positron in his studies on cosmic rays. This approach of Dirac opened up a new chapter in the field of physics and gave a special meaning to vacuum as the repository of all fundamental particles/waves corresponding to particles. The concept of vacuum which was absence of everything got transformed into the source of everything.

About this vacuum, Dirac himself says:

“All matter is created out of some imperceptible substratum ...

Nothingness ... unimaginable and undetectable.

But it is a peculiar form of nothingness out of which all matter is created.”

The role of vacuum as the repository of all particles is beautifully demonstrated in a complex phenomenon discovered in cosmic rays. The phenomenon is known as the Extensive Air Shower. A very high energy proton or heavy nucleus arrives at the top of the earth's atmosphere and through the initiation of nuclear and electromagnetic cascades leads to the production of a billion or more particles spread over several square kilometers by the time the shower reaches sea level or mountain altitude. When one goes into detailed mechanisms that are behind this transformation of just one particle into billions of particles with very different properties, one sees the dominant role of energy, and of the quantum mechanical vacuum in and around the air nuclei – resulting in the production of a variety of mesons, hyperons, nucleons and anti-nucleons, decays of the mesons into other particles, creation of electron positron pairs by the gamma rays produced in the decays of mesons etc. Such a grandiose emergence of such a large number of particles all hidden normally in the vacuum could never have been imagined or accounted for in the classical picture. It goes to the credit of quantum mechanics and the theories of Heisenberg, Dirac and others on particle production and cascade developments that such a phenomenon could be figured out and explained in all details.

These are a few typical examples of how in the area of physics it became necessary to give up many conventional concepts and ideas in the light of new experimental results and discoveries. The most significant realization on the part of the physicist was the recognition of the dominant role of the substratum thus removing many barriers in his progress towards understanding many aspects of the physical world. Perhaps a similar approach is called for in life sciences too to explain complex phenomena like Consciousness – to remove the observer-observed barrier and life-nonlife barrier too.

Highlighting this underlying quantum reality, David Hodgson writes in his book 'Mind Matters',

"Mind can to some extent be said to be a function of brain, but only if brain is understood not as the detectable macroscopic object, but as the quantum reality underlying both this object and the mental events of consciousness. Mind and brain are manifestations of and view points towards, a "single reality"; but with important differences, in particular in relation to the development over time of this reality and (specifically) the causes and explanations of such developments".

While science is moving towards this oneness as the approach to reality for its own reasons, is it not exciting that philosophers both in the East and West had arrived at the same conclusion by very different considerations and methodologies? This concept of oneness of the underlying substratum has been termed differently in different philosophies – Brahman in Vedanta, Sunyata in Buddhism, Tao in Chinese philosophies. Of course the contents and mechanisms by which this oneness manifests as the World – the Cosmos are very different.