Speculations on a Unified Theory of Matter and Mind*

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Abstract

Physics is so successful today in understanding the nature of matter. What can it say about mind? Is it possible to have a unified theory of matter and mind within the framework of modern science? Is Consciousness an accident or is it a natural consequence of laws of nature? Are these laws of nature the same as the laws of physics? We make an attempt here to unify mind with matter based on an extended formalism borrowed from Quantum theory where information plays a more fundamental role than matter or thought.

1 Introduction

Most of the physicists today believe that we are very close to a unified theory of matter (UTM) based on p-brane theory (a variant of String [1-brane] theory) [1]. This theory has been well motivated by the successes (from microchips to satellites) and the difficulties (the presence of infinities) of Quantum Gauge Field Theories (QED, Electro-Weak theory, GUT and SUSY GUT etc.) most of which are based on solid experimental evidences (measuring Lande g-factor of electron up to 10 significant places, prediction of Z boson etc.). This ‘theory of everything ‘ tells us that all carbon atoms (after they are born out of nucleosynthesis in the core of stars) in this universe are the same in space and in time, and thus is unable to explain why the carbon atoms present in a lump of roughly three pound of ordinary matter the human brain – give rise to such ineffable qualities as feeling, thought, purpose, awareness and free will that are taken to be evidence for ‘consciousness’!

Is Consciousness an accident caused by random evolutionary processes in the sense that it would not evolve again had the present universe to undergo a ‘big crunch’ to start with another ‘big bang’? NO! It is a fundamental property that emerges as a natural consequence of laws of nature. Are these laws of nature different from laws of physics? Is there a way to expand the UTM to incorporate consciousness? In this paper I make an attempt to point out a possible direction for such an expansion to achieve a unified theory of matter and mind by considering ‘information’ to be more fundamental than matter and energy.

Nature manifests itself not only at the gross level of phenomena (accessible to direct senses) but also at the subtle level of natural laws (accessible to ‘refined ‘ senses). Consciousness is the ability to access nature at both these levels. Hence everything in nature is conscious, but there is a hierarchy in the level of consciousness. Although animals, plants and few machines today can access to the gross level of nature, access to the subtle level seems to be purely human. In this sense a layman is less conscious compared to a scientist or an artist. (Is it possible that a level of consciousness exists compared to which a scientist or an artist of today may appear a layman?) Once everything (both matter and mind) is reduced to information it is possible to define consciousness as the capability to process information. Because any form of our access to nature is based on processing information with varying degree of complexity. The words process and complexity will be defined in the following. Now I proceed to elaborate the claims (italicized above) but due to the constraint of printing space I will be brief here and the details of this scheme will be given elsewhere.

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2 Matter

2.1 Phenomena

Some animals like dogs (in listening to ultrasound) and bats (in sensing prey through echo technique) are better equipped than humans when it comes to direct sense experiences. But unlike animals, humans have found out methods to extend their sense experiences through amplification devices like telescopes, microscopes etc. The summary [2] of such sense experiences (direct and extended) acquired over the last five hundred years (equivalent to one second in a time-scale where the age of the universe is equal to a year) is that our universe extends in space from the size of an electron ($10^{17}$ cm as probed at LEP colliders at CERN, Geneva) to size of galactic super-clusters ($10^{30}$ cm as probed by high redshift measurements). The theoretical possibility of Planck length ($10^{33}$ cm) allows for further extension in space.

Our grand universe extending over more than 60 orders of magnitude in space has been constantly changing over the last 12 billion years! Living systems seem to have evolved out of non-living systems. Consciousness seems to have evolved out of living systems. Is the dramatic difference between animate and inanimate, conscious and unconscious simply a difference in their ability to process information? At the level of phenomena nature is so vast and diverse compared to the size and comprehension of human beings that one wonders how the collective inquiring human minds over the centuries could at all fathom the unity behind this diversity. This simply testifies the triumph of human mind over the physical limitations of its body. Because the human mind is capable of reaching a synthesis (an advanced form of information processing) based on careful observations of diverse phenomena.

2.2 Inanimate

2.2.1 Manifold

Till Einstein, everybody thought ‘absolute space’ is the arena (mathematically, a manifold) on which things change with ‘absolute time’. In special theory of relativity (STR) he redefined the manifold to be flat space-time ($3 + 1$) by making both space and time relative with respect to inertial observers but keeping space-time (SpT) absolute. In general theory of relativity (GTR) he propounded this manifold to be curved space-time that can act on matter unlike the flat space-time. Then the Quantum Theory (QT, the standard version, not the Bohmian one) pointed out this manifold to be an abstract mathematical space called Hilbert space since the space-time description of quantum processes is not available. Quantum Field Theory (QFT) that originated in a successful merge of QT and STR requires this manifold to be the Quantum Vacuum (QV). Unlike the ordinary vacuum, QV contains infinite number of ‘virtual’ particles that give rise to all matter and interactions [3]. Every quantum field has its own QV and a successful amalgamation of QT and GTR (called Quantum Gravity, and yet to be achieved) may connect the curved space-time with the QV of gravitational field. Finally, String (or p-brane) theory demands all fundamental entities to be strings (or p-branes) in ten-dimensional space-time. This evolution in our understanding clearly shows the necessity and importance of a background manifold to formulate any scientific theory.

2.2.2 Basic Constituents

Energy and matter were considered to be the two basic constituents of our universe till Einstein showed their equivalence through $E=mc^2$. All forms of energy are interconvertible. Matter in all its forms (solid, liquid, gas and plasma) consists of atoms. The simplest of all atoms is the hydrogen atom that contains an electron and a proton. If one considers the (now outdated) Bohrian picture of hydrogen atom being a miniature solar system where the electron revolves around the proton in circular orbit then one realizes that most of the hydrogen atom is empty space. This means that if one blows up the hydrogen atom in imagination such that both electron and proton acquire the size of a football each then they need to be separated by 100 km or more! Hence one would think that even if 99.99% of the hydrogen atom consists of vacuum the point-like electron and proton are material particles. But that is not so.

The elementary particle physics tells us that all the visible matter (composition of dark matter is not yet surely known) in the universe is made of six leptons and six quarks along with their
antiparticles. Although they are loosely called *particles* they are not like the ordinary particles we experience in daily life. A ‘classical’ particle is *localized* and *impenetrable* whereas a ‘classical’ wave can be extended from minus infinity to plus infinity in space and many wave modes can simultaneously occupy the same space (like inside the telephone cable). But with the advent of quantum mechanics this seemingly contradictory differences between particle and wave lost their sharpness in the quantum world. A quantum object can simultaneously ‘be’ a particle and a wave until a measurement is made on it. According to QFT all fundamental entities are quantum fields (not material in the conventional sense) that are neither particle nor wave in the classical sense.

### 2.2.3 Evolution

Despite various specializations, all physical sciences share a common goal: given the complete specification of a physical system at an initial time (called the initial conditions) how to predict what will it be at a later time. To predict with exactness one needs the accurate initial conditions and the laws that govern the evolution of the system (called the dynamical laws). Either the lack of exact specifications of initial conditions or the intractability of huge number of equations (that express dynamical laws) can lead to a probabilistic description rather than a deterministic one. However, there are *chaotic* systems that can be both deterministic yet unpredictable because of their extreme sensitivity to initial conditions. Apart from dynamical laws there are other laws like \( E=mc^2 \) etc., which do not involve time explicitly. Could there be laws at the level of initial conditions that guide us to choose a particular set over another?

A physical law is like the hidden thread (unity) of a garland with various flowers representing diverse natural phenomena. Its character seems to depend on characteristic scales (denoted by *fundamental constants* like Planck length, Planck’s constant, and speed of light etc). Why should there be different set of laws at different scales? Most physicists believe that quantum mechanics is universal in the applicability of its laws like Schrödinger’s equation and classicality of the everyday world is a *limiting case*. But there exists no consensus at present regarding the emergence of this limiting case.

### 2.2.4 Guiding Principles

How does one formulate these physical laws? The principle of *relativistic causality* helps. Do physical laws change? Is there a unity behind the diversity of laws? Is it possible to understand nature without laws? The concept of symmetry (invariance) with its rigorous mathematical formulation and generalization has guided us to know the most fundamental of physical laws. Symmetry as a concept has helped mankind not only to define ‘beauty’ but also to express the ‘truth’. Physical laws tries to quantify the truth that appears to be ‘transient’ at the level of phenomena but symmetry promotes that truth to the level of ‘eternity’.

### 2.2.5 Interactions

The myriad mosaic of natural phenomena is possible because, not only each fundamental entity evolves with time but also it can interact with the other basic constituents. All the physical interactions (known so far) can be put into four categories: (i) gravitational interaction (the force that holds the universe), (ii) electromagnetic interaction (the force that holds the atom, and hence all of us), (iii) strong nuclear interaction (the force that holds the nucleus), and (iv) weak nuclear interaction (the force that causes radioactive decay). At present (ii) and (iv) are known (observationally) to be unified to a single force called ElectroWeak. Grand unified theories (GUT) and their extensions (SUSY GUT) for (ii), (iii) and (iv) do exist. Ongoing research aims to unify (i) with such theories.

According to QFT the basic matter fields interact by exchanging messenger fields (technically called *gauge fields*) that define the most fundamental level of communication in nature. Both matter fields and gauge fields originate in the fluctuations of QV and in this sense everything in universe including consciousness is, in principle, reducible to QV and its fluctuations [4]. Communication in nature can happen either via the *local* channel mediated by gauge fields or by the *nonlocal* EPR [5] type channels (through entanglement) as was demonstrated by recent *quantum teleportation* experiments.
2.2.6 Composite Systems

Till the importance of quantum entanglement was realized in recent times the whole was believed to be just the sum of parts. But the whole seems to be much more than just the sum of parts in the ‘quantum’ world as well as classical systems having complexity. It makes quantum entanglement a very powerful resource that has been utilized in recent times for practical schemes like quantum teleportation, quantum cryptography and quantum computation. Quantum nonlocality indicates that the universe may very well be holographic in the sense that the whole is reflected in each part.

2.3 Animate

2.3.1 Manifold

Space-time (3 + 1) is the manifold for all biological functions at the phenomenal level that can be explained by classical physics. If one aims to have a quantum physical explanation of certain biological functions then the manifold has to be the Hilbert Space.

2.3.2 Basic Constituent

Cell is the basic constituent of life although the relevant information seems to be coded at the subcell (genetic) level. Neuron (or Microtubules and Cytoskeletons) could be the physical substratum of brain depending on classical (or quantum) viewpoint.

2.3.3 Evolution

Does biological evolution happen with respect to the physical time? If yes, then will the physical laws suffice to study biological evolution in the sense they do in chemistry? If no, then is the biological arrow of time different from the various arrows of physical time (say, cosmological or the thermodynamical arrow of time)? Is there a need for biological laws apart from physical laws to understand the functioning of biological systems?

2.3.4 Guiding Principles

Survivability is the guiding principles in biological systems. Organisms constantly adapt to each other through evolution, and thus organizing themselves into a delicately tuned ecosystem. Intentionality may also play a very important role in the case of more complex biosystems.

2.3.5 Interactions

The interaction occurs by exchange of chemicals, electric signals, gestures, and language etc. at various levels depending upon the level of complexity involved.

2.3.6 Composite Systems

Composite systems are built out of the basic constituents retaining the relevant information in a holographic manner. The genetic information in the zygote is believed to contain all the details of the biology to come up later when the person grows up. The genes in a developing embryo organize themselves in one way to make a liver cell and in another way to make a muscle cell.

2.4 Discussions

2.4.1 How ‘material’ is physical?

Anything that is physical need not be ‘material’ in the sense we experience material things in everyday life. The concept of energy is physical but not material. Because nobody can experience energy directly, one can only experience the manifestations of energy through matter. Similarly the concept of a ‘classical field’ in physics is very abstract and can only be understood in terms of analogies. Still more abstract is the concept of a ‘quantum field’ because it cannot be understood in terms of any classical analogies. But at the same time it is a wellknown fact in modern physics that all fundamental
entities in the universe are quantum fields. Hence one has to abandon the prejudice that anything ‘physical’ has to be ‘material’.

2.4.2 Is reductionism enough?

The reductionist approach: observing a system with an increased resolution in search of its basic constituents has helped modern science to be tremendously successful. The success of modern science is the success of the experimental method that has reached an extreme accuracy and reproducibility. But the inadequacy of reductionism in physical sciences becomes apparent in two cases: emergent phenomena and quantum nonlocality. Quantum nonlocality implies a holographic universe that necessitates a holistic approach [6].

Though it is gratifying to discover that everything can be traced back to a small number of quantum fields and dynamical laws it does not mean that we now understand the origin of earthquakes, weather variations, the growing of trees, the fluctuations of stock market, the population growth and the evolution of life? Because each of these processes refers to a system that is complex, in the sense that a great many independent agents are interacting with each other in a great many ways. These complex systems are adaptive and undergo spontaneous self-organization (essentially nonlinear) that makes them dynamic in a qualitatively different sense from static objects such as computer chips or snowflakes, which are merely complicated. Complexity deals with emergent phenomena. The concept of complexity is closely related to that of understanding, in so far as the latter is based upon the accuracy of model descriptions of the system obtained using condensed information about it [7].

In this sense there are three ultimate frontiers of modern physics: the very small, the very large and the very complex. Complex systems cease to be merely complicated when they display coherent behaviour involving collective organization of vast number of degrees of freedom. Wetness of water is a collective phenomenon because individual water molecules cannot be said to possess wetness. Lasers, super-fluidity and super-conductivity are few of the spectacular examples of complexity in macroscopic systems, which cannot be understood alone in terms of the microscopic constituents. In every case, groups of entities seeking mutual accommodation and self-organization somehow manage to transcend the individuality in the sense that they acquire collective properties that they might never have possessed individually. In contrast to the linear, reductionist thinking, complexity involves nonlinearity and chaos and we are at present far from understanding the complexity in inanimate processes let alone the complexity in living systems.

2.4.3 Emergence of Life

Is life nothing more than a particularly complicated kind of carbon chemistry? Or is it something subtler than putting together the chemical components? Do computer viruses have life in some fundamental sense or are they just pesky imitations of life? How does life emerge from the quadrillions of chemically reacting proteins, lipids, and nucleic acids that make up a living cell? Is it similar to the emergence of thought out of the billions of interconnected neurons that make up the brain? One hope to find the answer to these questions once the dynamics of complexity in inanimate systems is well understood.

3 Mind

3.1 Phenomena

Mind is having three states: awake, dream, dream-less sleep. Mind is capable of free-will, self-perception (reflective) and universal perception (perceptual) in its ‘awake’ state. Can it be trained to have all these three attributes in the states of dream and dream-less sleep? Can there be a fourth state of mind that transcends all the above three states? Where do the brain end and the mind begin? Due to its global nature, mind cannot lie in any particular portion of the brain. Does it lie everywhere in the brain? This would require nonlocal interactions among various components of the brain. If there were no such nonlocal communication then how does the mind emerge from the brain?

Can anybody think of anything that transcends space-time? Is mind capable of thinking something absolutely new that has not been experienced (directly or indirectly) by the body? Nobody can think
of anything *absolutely* new. One can only think of a new way of arranging and/or connecting things that one has ever learnt. In this sense intellect is constrained by reason whereas imagination is not. But imagination is not acceptable to intellect unless it is logically consistent with what is already known. Imagination helps to see a new connection but intellect makes sure that the new connection is consistent with the old structure of knowledge. This is the way a new structure in knowledge is born and this process of acquiring larger and larger structure (hence meaning or synthesis) is the learning process. Science is considered so reliable because it has a stringent methodology to check this consistency of imagination with old knowledge.

Can one aspire to study the mind using methodology of (physical) sciences? Seeing the tremendous success of physical sciences in the external world one would think its methodology to work for understanding the inner world. It is not obvious a priori why should not QT work in this third ontology when it has worked so successfully with two different ontologies? We aim to understand nature at a level that transcends the inner and the outer worlds by synthesizing them into a more fundamental world of quantum information.

### 3.2 Formalism

#### 3.2.1 Manifold

A physical space-time description of mind is not possible because thoughts that constitute the mind are *acausal*: it does not take 8 minutes for me to think of the sun although when I look at the sun I see how it was 8 minutes ago. We will assume that it is possible to define an abstract manifold for the space of thoughts (say, T-space). An element of T-space is a thought-state (T-state) and the manifold allows for a continuous change from one T-state to another. I presume that T-space is identical with mind but it need not be so if mind can exist in a thoughtless but awake state, often called *turiya*.

#### 3.2.2 Basic Constituent

How does one define a T-state? That requires one to understand what is a ‘thought’? A thought always begins as an idea (that could be based on self and universal perception) and then undergoes successive changes in that idea but roughly remaining focused on a theme. Change from one theme to another is triggered by a new idea. Hence I would suggest that the basic constituent of T-state is *idea*. An idea is like a ‘snapshot’ of experience complete with all sense data whereas a thought (T-state) is like an *ensemble* (where each element is not an exact replica of the other but has to be very close copy to retain the focus on the theme) of such snapshots.

#### 3.2.3 Evolution

There are two types of evolution in T-space. First, the way an ensemble of ideas evolves retaining a common theme to produce a thought. To *concentrate* means to linger the focus on that theme. This evolution seems to be nonlinear and nondeterministic. Hence the linear unitary evolution of QT may not suffice to quantify this and will be perhaps best described in terms of the mathematics of *self-organization* and *far-from-equilibrium phenomena*. [On the practical side the time-tested techniques of Yoga teach us how to linger the focus on a theme through the practice of *dharana, dhyan and samadhi*.] The second type involves a change from one particular thought into another and this evolution could be linear and perhaps can be calculated through a *probability amplitude* description in the line of QT. Given the complete description of a thought at an initial time the refutability of any theory of mind amounts to checking how correctly it can predict the evolution of that thought at a later time.

#### 3.2.4 Guiding Principles

If the guiding principle for evolution in biological world is *survivability* then in T-space it is *happiness-ability*. A constant pursuit of happiness (although its definition may vary from person to person) guides the change in a person’s thoughts. Each and every activity (begins as mental but may or may not materialize) is directed to procure more and more happiness in terms of sensual pleasures of the body, emotional joys of the imagination and rational delights of the intellect.
3.2.5 Interactions

Can a thought (mind) interact with another thought (mind)? Can this interaction be similar to that between quantum fields? Perhaps yes, only if both thought and quantum fields can be reduced to the same basic entity. Then it will be possible for thought (mind) to interact with matter. What will be the messenger that has to be exchanged between interacting minds or between interacting mind and matter? This ultimate level of communication has to be at the level of QV and hence it may amount to silence in terms of conventional languages. But can any receiver (either human mind or any other mind or equipment) be made so sensitive to work with this ultimate level of communication? Interaction with the environment is believed to decohere a quantum system that causes the emergence of classicality in physical world. A completely isolated system remains quantum mechanical. Can a completely isolated mind exhibit quantum mechanical behaviour in the sense of superposition and entanglement?

3.2.6 Composite Systems

In the T-Space a thought is an ensemble of ideas and a mind-state is composed of thoughts. Behaviour, feeling and knowledge of self and universe are in principle reducible to composite subsets in the T-space.

3.3 Discussions

3.3.1 Working definition of Consciousness

Consciousness (at the first level) is related to one's response \( R \) to one's environment. This response consists of two parts: habit \( H \) and learning \( L \). Once something is learnt and becomes a habit it seems to drop out of consciousness. Once driving a bicycle is learnt one can think of something else while riding the bicycle. But if the habit changes with time then it requires conscious attention. We have defined learning earlier as a process to find commensurability of a new experience with old knowledge. One has to learn anew each time there is a change in the environment. Hence consciousness is not the response to the environment but is the time of rate of change of the response i.e.

\[
C = \frac{dR}{dt}
\]

where, \( R = H + L \).

The hierarchy in consciousness depends on the magnitude of this time derivative. Everything in the universe can be fit in a scale of consciousness with unconscious and super-conscious as the limit points. It is obvious that all animals show response to their environment, so does some of the refrigerators, but there is a hierarchy in their response. Through the use of 'cresco-graph' and 'resonant cardio-graph' of J. C. Bose one can see the response of botanical as well as inanimate world. We cannot conclude that a stone is unconscious just because we cannot communicate with it using our known means of communication. As technology progresses, we will be able to measure both the response function \( R \) and its time derivative. If this is the definition what can it tell about the future evolution of humans? My guess is that we would evolve from conscious to super-conscious in the sense that genes will evolve to store the cumulative learning of the human race.

3.3.2 Emergence of Consciousness

The first step in understanding consciousness consists of using reductionist method to various attributes of consciousness. A major part of the studies done by psychologists (and their equivalents doing studies on animals) and neuro-biologists falls under this category. Such studies can provide knowledge about mind states (say \( M_1, M_2, \ldots \)) but cannot explain the connection between these mind states with the corresponding brain states (say \( B_1, B_2, \ldots \)). Because this kind of dualistic model of Descarte would require to answer a) where is mind located in the brain, and b) if my mind wants me to raise my finger, how does it manage to trigger the appropriate nerves and so on in order for that to happen without exerting any known forces of nature?

To find out how the mind actually works one needs to have a theory of mind, that will relate the sequence of mental states \( M_1, M_2, M_3, \ldots \) by providing laws of change (the dynamical laws for the
two types of evolution discussed above) that encompass the mental realm after the fashion of the theory of matter that applies to the physical realm, with its specific laws. Such a theory of mind is possible if we synthesize the results of studies on attributes of consciousness to define the exact nature of the manifold and the basic entities of the T-space (or Mind-Space). Once this is achieved then one can attempt to explain the emergence of consciousness taking clues from complexity theory in physical sciences. But such an extrapolation will make sense provided both M-states and B-states can be reduced to something fundamental that obeys laws of complexity theory. We propose in the next section that information is the right candidate for such a reduction.

3.3.3 Role of Indian Philosophy (IP)

(1) Unlike the Cartesian dichotomy of mind and body some schools of IP like Vaisheshika and Yoga treat both mind and body in a unified manner. Since (western) science is based on Cartesian paradigm it cannot synthesize mind and body unless it takes the clue from oriental philosophies and then blend it with its own rigorous methodology.

(2) In terms of sense awareness, awake, dream and dream-less sleep states are often called as conscious, subconscious and unconscious states. A great conceptual step taken by IP in this regard is to introduce a fourth state of mind called turiya that is defined to be none of the above but a combination of all of the above states. This state is claimed to be the super-conscious state where one transcends the limitations of perceptions constrained by space-time (3 +1). Patanjali has provided very scientific and step by step instructions to reach this fourth state through samayama (dharana, dhyana and samadhi are different levels of samayama). The scientific validity of this prescription can be easily checked by controlled experiments. Nobody can understand the modern physics without going through the prerequisite mathematical training. It will be foolish for any intelligent lay person to doubt the truth of modern physics without first undergoing the necessary training. Similarly one should draw conclusion about yogic methods only after disciplined practice of the eight steps of yoga.

(3) IP can provide insights regarding the role of mind in getting happiness and thus a better understanding of mind itself. Happiness lies in what the mind perceives as pleasurable and hence the true essence of happiness lies in mind and not in any external things. Once the body has experienced something mind is capable of recreating that experience in the absence of the actual conditions that gave rise to the experience in the first place. One can use this capacity of mind to create misery or ecstasy depending on one’s ability to guide one’s mind.

(4) There is a concept of anahata nada (the primordial sound) in IP. Sometimes the possibility of having a universal language (like Sandhya bhasa etc.) to communicate with everything in the universe is also mentioned. Modern physics tells us that the only universal language is at the level of gauge bosons and QV. Is there any connection between these two? Can a (human) mind be trained to transmit and receive at the level of QV?

(5) It is said that whole body is in the mind whereas the whole mind is not in the body. How does mind affect the body? If one believes in the answer given by IP then the results obtained in this regard by the western psychology appears to be the tip of the iceberg only. Can science verify these oriental claims through stringently controlled experiments?

4 Unification

4.1 Information

Information seems to be abstract and not real in the sense that, it lies inside our heads. But information can, not only exist outside the human brain (i.e. library, a CD, internet etc.) but also can be processed outside human brain (i.e. other animals, computers etc.). Imagine a book written in a dead language, which nobody today can decipher. Does it contain information? Yes. Information exists. It does not need to be perceived or understood to exist. It requires no intelligence to interpret it. In this sense information is as real as matter and energy when it comes to the internal structure of the universe [8]. But what we assume here is that information is more fundamental than matter and energy because everything in the universe can be ultimately reduced to information.

Information is neither material nor non-material. Both, quantum fields and thoughts can be reduced to information. If the human mind is not capable (by the methods known at present) of
understanding this ultimate information then it is the limitation of the human mind. This may not
remain so as time progresses. The whole of physical world can be reduced to information [9]. Is
information classical or quantum? There are enough indications from modern physics that although
it can be classical at the everyday world it is quantum at the most fundamental level. The quantum
information may have the advantage of describing the fuzziness of our experiences.

4.2 Formalism

4.2.1 Manifold

The manifold is an information field (I-field) for classical information (like that of Shannon or Fisher
etc.) Hilbert space of QT is the manifold to study quantum information. But if quantum information
has to be given an ontological reality then it may be necessary for the manifold to be an extended
Hilbert space.

4.2.2 Basic Constituent

A bit or a qubit is the basic entity of information depending on whether it is treated as classical or
quantum respectively. Information can be of two types: kinetic and structural, but they are convertible
to each other [8].

4.2.3 Evolution

All organized systems contain information and addition of information to a system manifests itself by
causing the system to become more organized or reorganized. The laws for evolution of information are
essentially laws of organization. Are these laws different from the physical laws? Is there an equivalent
in the world of information of fundamental principles like principle of least action in physical world?

4.2.4 Guiding Principles

Optimization seems to be the guiding principle in the world of information. What gives rise to the
structure in the information such that we acquire an understanding or meaning out of it? Is there a
principle of least information to be satisfied by all feasible structures?

4.2.5 Interactions

The interaction at the level of information has to be the ultimate universal language. What could
be that language? The only fundamental language known to us is that of the gauge fields that
communicate at the level of QV. Could the gauge fields serve as quanta of information? How far is
this language from the conventional language? Can this help us to communicate with not only with
other creatures incapable of our conventional language but also with the inanimate world? Time is
not yet ripe to answer these questions.

4.2.6 Composite Systems

How can every composite system of information (like a gene or a galaxy) be expressed in terms of bits
or qubits? Does the holographic principle also apply to information?

4.3 Discussions

4.3.1 Consciousness and Information

There is no doubt that sooner or later all attributes of consciousness can be reduced to information.
This is just a matter of time and progress in technology. That will complete the understanding of
consciousness at the gross level of phenomena but will harbinger the understanding of consciousness at
the subtle level of laws. The synthesis of the phenomenological studies of consciousness will be possible
by treating information as the most basic ontological entity, which can unify mind and matter. The
emergence of consciousness will be understood in terms of nonlinear, far-from-equilibrium complex
processes that lead to spontaneous self-organization and adaptation of structures in the manifold of quantum information.

Consciousness will be seen as the ability to process quantum information in an effective way. Depending on the degree of complexity involved the processing would encompass activities starting from the way a planet knows which is the path of least action to the way modern supercomputers do simulations of reality to the way a scientist makes a discovery or an artist traps beauty on a canvas through the nuances of truth. The limit points of unconscious and super-conscious would correspond to the limiting cases of no information processing and infinite information processing respectively.

Subconscious will be interpreted as partial information processing.

Every entity in the universe has to take a decision at every moment of time for its existence although the word existence may mean different things to different entities. The chance for continuation of existence is enhanced if the best decision on the basis of available information is taken. This is a process of optimization and the more conscious an entity is more is its ability to optimize.

4.3.2 Limitations of understanding

Is there any fundamental principle (or theorem) that puts limit on the understanding of both mind and matter by reducing them to information and then applying methodology of physical sciences to understand life and consciousness as emergent phenomena? Since this approach heavily relies on mathematics the limitations of deductive logic as pointed out by Gödel in his famous incompleteness theorem may put the first limit. The second constraint may come from QT if it turns out (after having rigorous information theoretic formulation of both matter and mind) that the information related to mind is complementary to the information found in matter. I personally feel that this is quite unlikely because I believe that information at the fundamental level cannot be dualistic.

5 Conclusions

Unlike the Cartesian duality between mind and body, understanding consciousness requires first to understand matter and mind in a unified way. This can be achieved by giving information the most primary status in the universe. Then a generalized theory of quantum information dynamics has to be formulated (see the table (in the last page): The World Matrix, for a summary). The line of attack involves three steps: 1) understanding emergent phenomena and complexity in inanimate systems, 2) understanding life as emergent phenomena, and 3) understanding consciousness as emergent phenomena. The attributes of consciousness can be understood only by a prudent application of both reductionism and holism. But the emergence of consciousness will be understood as an emergent phenomenon in the sense of structural organizations in the manifold of information to yield feasible structures through which we attribute meaning and understanding to the world.

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7 References

[1] Sarkar U., 2001, *New Dimensions New Hopes*; arXiv: hep-ph/0105274
[2] Davies P., 1989, *The New Physics*, Cambridge University Press.
[3] Sreekantan B. V., 2001, this conference proceeding
[4] Sreekantan B. V., 1999, *Scientific Explanations and Consciousness*, Proceedings of the national conference on Scientific and Philosophical Studies on Consciousness, held at NIAS, Bangalore.
[5] Einstein A, Podolsky B., Rosen N (EPR), 1935, *Quantum theory and Measurement*, edit. By Zurek, W. H. and Wheeler, J. A.
[6] Bohm D. and Hiley B.,1993, *The Undivided Universe*, Routledge, London.
The World Matrix: (Summary of various Worlds)

| Character           | Physical                          | Biological                        | Mental                     | Information                           |
|---------------------|-----------------------------------|-----------------------------------|----------------------------|---------------------------------------|
| **Manifold**        | SpT $(3 + 1)$, Hilbert Space QV, SpT $(10)$ | SpT $(3 + 1)$, Hilbert Space      | M-Space (Abstract Mathematical Space) | I-Field, Extended Hilbert Space        |
| **Basic Constituents** | Wave-function Quantum fields Strings p-branes | Cell, Neuron, Micro-tubule Cyto-skeleton | Idea (based on self or universal perception | Bit (classical) Qubit (quantum)        |
| **Evolution**       | Phys. Laws (mostly diff. equations) | Phys. Laws Bio. Laws              | Laws for evolution of thought | Laws for evolution of organization     |
| **Guiding Principles** | Symmetry (Group Theoretical)      | Survivability Intentionality      | Happiness-Ability           | Optimization                          |
| **Interactions**    | Gravity, Electro-weak, Strong Nuclear Interaction | Chemicals, Electric Signals, Language, Gesture | Primordial Sound or Vibrations | Local, and Non-local (EPR) channels   |
| **Composite Systems** | Many-body Systems with or without interactions | Plants, Animals                  | Thought ( Ensemble of Ideas with ordering) | Complex Systems with Hierarchy in Organization |