Quantum Psyche

Quantum Field Theory of the Human Psyche

by

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Abstract

We postulate that the human psyche is a particular excitation of an underlying universal psychic (consciousness) quantum field. The human psyche is postulated to have a representation similar to a quantum system, with virtual and physical states corresponding to the potentiality and actuality of the human mind. We postulate that free will plays a central role in the transition from potentiality to actuality and vice versa. We model the psyche as a non-Abelian and supersymmetric quantum field, with its interactions mediated by another supersymmetric vector quantum field. We propose a model for the ground state of the human species, and show how an individual's psyche is created as excitations on the individual's ground state. We briefly give a quantum description of the waking and sleeping states of the human psyche, and lastly propose a model for the substructure of the human psyche based on the ideas of bound and entangled states.

1 Introduction

The subject of human consciousness[2] has intrigued mankind from the very inception of human society, and a search for a greater understanding of the human psyche has been an on-going endeavor, carried out in parallel to the striving for a greater understanding of nature.

Broadly speaking, there are two schools of thought regarding the study of human consciousness. The materialist school of thought holds that consciousness can, in principle, be fully explained by the properties of atoms and molecules that constitute the human brain, and that the laws of nature, and the laws of physics in particular, are sufficient for such an explanation. Many exponents of contemporary psychology also adhere to the materialist outlook. On the other hand, for the 'spiritually' inclined the explanation of human consciousness, and of the subjective and spiritual aspect of the human self, is usually taken to be the preserve of religion,

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[2]We use the terms psyche, consciousness, subjectivity, mind and so on interchangeably in this paper.

and is taken to be beyond the domain of science. In particular, some 'spiritually' inclined persons are of the view that there can be no mathematical and scientific theory for human consciousness, and that science can only be applied to the study of physical phenomena.

The philosophical position that we take in this paper lies in-between the materialist and 'spiritual' points of views. We hold that the laws of the material world cannot by themselves fully explain the phenomenon of human consciousness, and that human psyche is a reflection of dimensions of reality that are not contained in physical quantities (fields) that represent the physical processes and structures of matter. In this sense we do not subscribe to the materialist point of view. At the same time, we are of the view that human psyche can indeed be investigated quantitatively using mathematical models, which in principle can also be empirically tested. In this sense the study of human consciousness can be carried out by means and procedures that are quite similar to the scientific method used in the study of matter.

In particular, we approach the question of the human psyche from the point of view of quantum theory, and argue in favor of modelling the human psyche by using the mathematical formalism of quantum theory. A quantitative theory can also in principle be tested empirically, and we leave this aspect of the model for later research.

In creating a mathematical model for the human psyche there are two distinct and interrelated questions, namely the **representation** of the human psyche, and that of its **explanation** in terms of more fundamental and deeper concepts. These two aspects are closely interrelated, since only an appropriate representation will provide the requisite concepts and language required for explaining consciousness.

We will show that quantum theory provides a transparent and tangible representation of the human psyche. Moreover, once the structures and quantities of quantum theory are related to features of the human psyche, it then follows that many new and unexpected statements regarding the human psyche naturally follow from the inner logic of quantum theory.

2 Consciousness and Quantum Mechanics

The question about the essence of human consciousness and especially the fact that it is either a classical epiphenomenon or the manifestation of a quantum mechanism, or something else, have been considered by many authors during the last ten years. In particular it has been studied by Roger Penrose in his book *Shadows of the Mind* [1].

As pointed out by Stanley A. Klein [2] there are two ways of making quantum mechanics intervene in the mind-body problem. First, "the physics of quantum mechanics can be relevant to the neural correlates of awareness". In other words there could be quantum effects in the physical mechanisms taking place inside the brain.

Secondly, "the metaphysics of quantum mechanics may be essential to understanding the subjective nature of consciousness".

The first question has been raised by Roger Penrose. With Stuart Hameroff, an anesthesiologist at the University of Arizona, he has proposed that general anesthetics interact with neurons via quantum level events in neural microtubules, which transport chemicals down axons and dendrites. Another question raised by Penrose is : "Are long-range quantum effects able to produce measurable changes in neural activity?" According to him "the unity of a single mind can arise, in such a description, only if there is some form of quantum coherence extending across at least an appreciable part of the entire brain". For Stanley. A. Klein [2] and Bernard J. Baars [3] there is no evidence in the arguments of Roger Penrose that there exist

quantum effects in the physical processes taking place inside the brain.

"Consciousness is part of our universe, so any *physical theory* which makes no proper place for it falls fundamentally short of providing a genuine description of the world. I would maintain that there is yet no physical, biological, or computational theory that comes very close to explaining our consciousness... ", writes Roger Penrose.

From our point of view, the arguments of Roger Penrose lack for the existence of the unconscious. According to Bernard J. Baars, Penrose appears to deny unconscious mental processes altogether. Let us remind that there is a connection between conscious and unconscious processes that have been studied in the framework of Quantum Mechanics by W. Pauli and the psychoanalyst C. J. Jung, leading them to introduce the concept of synchronicity [4].

Even though the physical processes involved inside the brain, i.e. the neural activity, can be explained by classical mechanics without referring to quantum mechanics, there still remain "the intriguing link between quantum mechanics and the role of the observer" [2]. In other words we still have to ask the question: "Are observer effects in quantum mechanics and conscious experience the same?". "The challenge is to find a satisfactory way to associate the ≪observer≫ of subjective awareness with the ≪observer≫ of quantum mechanics" [2].

Even though the physics of quantum mechanics is not relevant to the neural correlates of awareness, the metaphysics of quantum mechanics may be essential to understand the subjective nature of consciousness [2].

Our paper does not deal with the existence of quantum effects in the neural activity of the brain but rather on the other aspects raised by S. A. Klein in his review of Roger Penrose's book *Shadows of the Mind*. One of these aspects is the link between quantum measurement in microscopic physics and the existence of conscious experience. Another aspect raised by Klein, related to the previous one, is the need to ask for the metaphysics of quantum mechanics to understand the subjective nature of consciousness.

As pointed out by Klein: "The big problem in the metaphysics of quantum mechanics is the question of where to place the split between the observer and the observed. The astonishing finding of von Neumann [5] is that its placement is irrelevant to any measured event. The split is moveable. Contrarily to previous dualities of Plato, Descartes and Kant that contain inconsistencies when the two sides are compared, there are no inconsistencies between the two halves of the quantum duality. Present quantum theory, with its flexible split placement, allows the neural correlates of awareness to be above the split (the neural correlates of awareness become the observer) and the remaining (unconscious) neural activity to be below. This is the placement advocated by von Neumann [5], Wigner [6] and Stapp [7]. Stapp, in particular, has been lucid in writing about the conscious act being connected with the reduction process".

We will deal with this problem in our paper. In section 5 we will assume that the concept of free will, a consequence of human awareness, is directly connected to decoherence, i.e. to the reduction process in quantum mechanics.

3 State space description of the Human Psyche

To represent the human psyche, we need to consider its salient characteristics. We all know that the mind can hold many ideas at the same time, and then choose to actualize any one of them. For instance, one can be reading a newspaper and think of drinking water at the same time. More complex superpositions of thoughts and ideas occur for example in solving difficult research problems in science. One also responds to external stimuli and forms ideas in response

to such stimuli. In quantum theory, any system is represented by a **state vector** that is an element of a linear vector space. We follow the approach of quantum theory and consider the individual human psyche, denoted by $|P>$, to be an element of the state space, whose elements are all possible states of the individual's psyche.

Suppose a person has been lost in a desert without water for days and is desperately thirsty; the psyche of such a thirsty person has only **one thought** in his mind, namely, that he needs to drink water.[3] We can represent the psyche of such a person as

$$|P>=|\text{water}> \tag{1}$$

The psyche thinking of only one thought is a possible state for a person.

In general, any idea – such as water in the above example – when it exists in a person's mind, will be represented by a state vector |Idea >. It is intuitively obvious to most people that some ideas are completely independent of other ideas, and others are not. For example, the idea of |water > has no connection with the idea of |lion >; ideas that are independent of each other are modelled in quantum theory as being orthogonal, and this is expressed as

$$<\text{lion}|\text{water}>=0 \tag{2}$$

Ideas that are directly related to each other, such as two breeds of dogs, are not orthogonal, and we have

$$<\text{Greyhound}|\text{Alsatian}>\neq 0 \tag{3}$$

Some ideas are combinations of more fundamental ideas; for example, one may think of a greeting card as a combination of orthogonal (independent) components such as the greeting, drawing, paper, ink and so on, and we can represent this by

$$|\text{Greeting Card}>=\text{c(1)}|\text{greeting}>+\text{c(2)}|\text{drawings}>+\text{c(3)}|\text{paper}>+\text{c(4)}|\text{ink}>+... \tag{4}$$

where the coefficients of the component ideas are complex numbers whose square modulus express the relative importance of the specific idea in the Greeting Card:

$$|c(1)|^2=0.90,\quad |c(2)|^2=0.05,\quad |c(3)|^2=0.01,\quad |c(4)|^2=0.01,...$$

Let us examine more closely the waking state of a person, which we denote by the state vector $|a>$. Suppose the wakened psyche is in a state in which the person has many **simultaneous** thoughts – he may be driving, and at the same time thinking of a problem at the office, and of picking up his daughter from school, and so on. The person's psyche is not completely in any one state, and is 'spread out' amongst many possible ones. The way such a state of multiplicity is represented in quantum mechanics is by **adding** the state vectors that represent the different ideas. Let us label the specific thoughts (states) of the psyche by |Idea(1) > , |Idea(2) >, ...|Idea(N) >, and assume for simplicity that all the ideas are orthogonal to each other. We represent the total psyche by the simplest possible means, again as is the case in quantum theory, by considering the individual's composite psyche to be the **superposition** of these thoughts, and hence have

$$|a>=c(1)|\text{Idea(1)}>+\text{c(2)}|\text{Idea(2)}>+...\text{c(N)}|\text{Idea(N)}> \tag{5}$$

$$<\text{Idea(i)}|\text{Idea(j)}>=\delta_{\text{i}-\text{j}} \tag{6}$$

[3]For the sake of simplicity, we will refer to a person as 'he', and will take it to refer to both the male and the female gender.

The coefficients $c(i)$ are complex numbers that quantify how important a particular idea is in the mind of the person. If one were to ask the person: "what are you thinking?", then the probability that he would say that he was thinking of Idea(i) is given by $|c(i)|^2$. In other words, asking a person what he or she is thinking is making an observation on the person's psyche.

Since the psyche is always in some state when it is observed, we need to have

$$\sum_{i=1}^{N} |c(i)|^2 = 1 \tag{7}$$

and the state $|P>$ is said to be normalizable. A state space consisting of only normalizable states is called a Hilbert space, and for the individual's psyche we denote it's Hilbert space by $\mathcal{P}$.

The representation of the undisturbed human psyche as a superposed state finds strong support in quantum theory. Consider the spin of an electron that can point either up or down. In quantum mechanics, the spin of an electron has two forms of existence, namely the physical and the virtual. When it is observed it is in a physical state in which the spin points **either** up **or** down. On the other hand, if it is not being observed the spin is in a virtual state in which the spin can simultaneously exist in two mutually exclusive states. Note that **every time** the spin is observed, it is found to point in only one direction. Hence the virtual state can never be directly observed by the five senses, and that is why one can never observe in nature a bizarre situation where a single entity is simultaneously in two mutually exclusive states. Nevertheless the existence of the virtual state has dramatic experimentally measurable consequences.

The virtual state in quantum theory is a superposed state of different possible states of the system. In quantum theory, only the human mind can 'see' the virtual state. It follows, since the mind can hold a superposed state of nature, the human psyche itself must possess a similar virtual state, and that is what we have represented in eq.5 above.

4 Consciousness and Self-Consciousness

What about the relationship of a person with his **own** psyche? Is the state of superposition something that can be resolved into the component ideas by the person himself, without any intervention by the external environment (which includes other people)?

Consciousness and self-consciousness differ in only one aspect, and which is that the 'object' for self-consciousness is consciousness itself. How does self-consciousness differentiate itself from consciousness?

We identify the rate of change of the psyche with self-consciousness, since it is only in the change of consciousness that self-consciousness can be experienced. Self-consciousness 'sees' consciousness in the process of time evolution. Another important feature of the consciousness and self-consciousness dialectic is that one can either be in a state of self-consciousness or of consciousness – one cannot be in both states simultaneously. One can either be carrying out an act that requires consciousness, such as doing a problem of arithmetic, or be aware of one's own state of consciousness, in this case being aware of oneself doing arithmetic. Consciousness and self-consciousness are two 'moments' of the human psyche; when self-consciousness views consciousness as a distinct entity, the human psyche has to identify itself with one of its aspect so as to view the other aspect as a separate entity. In normal circumstances a person is 'in-between' the two polar aspects of the consciousness and self-consciousness dialectic, and it is

the continuous **transitions** that the psyche undergoes between these two polar opposites that comprises the essential dynamism of the human psyche.

When self-consciousness critically observes consciousness, it finds that there is a wide range of thoughts that are being sustained by consciousness, and this collection of thoughts forms a superposed state. A superposed state of the psyche $|P>$ is a state of consciousness, and self-consciousness performs observations on consciousness in the process of the evolution of consciousness.

For a person who is involved in any particular activity, including theoretical work, one particular idea dominates; but even in such a circumstance, there is a whole battery of idea that are in the background of the person's mind, and form a superposed state with the dominant idea. Any particular idea that is in the consciousness of a person can become the central idea, and this process of bringing an idea from the background to the foreground can be thought of as an act of observation performed by the self-consciousness of the individual.

Another manner in which a person performs an observation on his own psyche is by self-consciousness acting on one of the ideas that is part of a superposed state – for example, he can go get a sandwich, and hence completely reduce his thoughts from an array of thoughts to one thought.

We can think of the superposed state of an individual as the condition of **potentiality** for the psyche, and the particular thought that the person **acts on**, be it a mental or physical action, as the actual state, or the **actuality**, of the person's psyche. [4]

We should not forget the existence of the unconscious. The unconscious is part of the psyche of an individual and, as we postulate it for conscious thoughts, is a linear superposition of state vectors. Like for the metaphysics of quantum mechanics, as mentionned in section 2 for the place of the split between the observer and the observed, the placement of the split between conscious thougths and the unconscious is irrelevant to any measured event [5]. This split is moveable. Conscious thoughts are above the split unlike unconscious states that are below the split but the position of the split is not well defined and moveable. This is the reason why the state $|P>$ associated to the psyche of an individual includes in itself conscious thoughts (consciousness) and the unconscious. Therefore there are no inconsistencies between the two halves of the quantum duality of the human psyche: consciousness and unconscious. It is also the reason why we can state that even if it seems that we can have only one thought at a time, consciousness remains a superposition of vector states.

Quantum theory of the human psyche, with its flexible split placement between consciousness and unconscious, allows the self-awareness of the observer to be above the split and the remaining unconscious activity to be below.

Let us consider in the next section how the conscious act is connected with the reduction process of the superposition of states of the human psyche via free will and decoherence.

5 Free Will and Decoherence

The concept of **free will** is naturally represented in our quantum model of the psyche. Free will operates in two distinct manners; in forming a superposed state, a person has freedom to

[4] Clearly there are questions whether we can at all represent the psyche using probability theory, since the underlying requirement in all probabilistic models is the need to repeat – under identical conditions – the experiment many times. One may wonder whether it is possible, even in principle, to repeat a person's mental state, and we leave this question for later discussion.

choose what are the states he includes in his mental state, namely he can choose the coefficients $c(i)$; the other manner in which free will operates is in the freedom of choosing to actualize a particular state |Idea(i) >.

More precisely, the virtual state of the human psyche is represented by the density matrix for a pure state given by

$$\rho = |a >< a| \tag{8}$$

where $|a >$ is given in eq.5. When the mind is observed either externally or by itself, the density matrix undergoes decoherence, and we have

$$\rho = |a >< a| \Rightarrow \text{Measurement} \Rightarrow \sum_{\text{i=1}}^{\text{N}} |\text{c(i)}|^2 |\text{Idea(i)} >< \text{Idea(i)}| \tag{9}$$

Free will acts to break the coherent state represented by ρ; on being observed, free will decides to actualize **one** of the states |Idea(i) > with probability $|c(i)|^2$. The manner in which the superposed state of the awake state $|a >$ was prepared will determine the coefficients $|c(i)|^2$.

Of course, no person has absolute freedom of will, since a person has to eat and sleep whether he or she likes it or not. Moreover, a person is often forced to think in certain ways due to external circumstances. Hence, there are also thoughts and states of the psyche that are created by external stimuli and circumstances, including the needs of the physical body. But within all these limitations, the mind still chooses to hold some ideas and actualize some ideas and not others. [5]

In conclusion, to a leading approximation one can think of the state vector for the psyche $|P >$ as refereing to both, the state of the psyche as seen by another person, as well as the psyche as seen by the person himself. The state $|P >$ represents the **virtual** and **potential** state of the human psyche. The transition from the virtual to the physical state is made by the free will of the person – either as a consequence of an act of measurement carried out by the environment, or by the person himself (by an act of self consciousness) – leading to a **physical** and **actual** state.

6 Universal Quantum Field Underlying the Human Psyche

What is the individual human psyche 'made out of'? What is its relation with the psyche of other individuals? Our starting point in understanding the human psyche is to consider it be a universal phenomena, and not something specific and unique that only human beings possess. Subjectivity is as universal and 'objective' as an electron. Similar to an electron, we hold that consciousness can occur anywhere in the universe, and is governed by the same laws of consciousness as those that determine the structure and processes of human consciousness.

All electrons in the universe are excitations of the same underlying electron quantum field that extends throughout space and time; an electron in a distant galaxy is identical to the electron in our living room because both are excitations of the same electron quantum field. The quantum field can be thought of as a universal ocean, and individual electrons as being

[5]The electron has no 'free will' and hence it is a complete mystery in quantum mechanics as to how the electron 'chooses' to actualize a particular state when it is observed.

waves on this ocean. Every fundamental particle like the electron, photon (which is the quantum of ordinary light) and so on have their own quantum field.

Quantum fields come in two varieties, of which the electron field represents one category called fermions, and the other category is called boson, of which the photon is a typical example. Fermions are generally localized in space and all ordinary matter – like atoms – is composed out of fermions. The salient property of fermions is that no two identical fermions can occupy the same point of space, called the exclusion principle; for example two electrons cannot ever simultaneously be found at the same point of space. Bosons are the mediators of interactions between the fermions; and unlike fermions, there can be any number of bosons at a single point of space.

Quantum fields can be used to model the 'stuff' that consciousness is made out of. We postulate that human subjectivity is constituted by quantum fields that span all of space and time; a particular psyche, similar to a specific electron, is an excitation of the quantum field.[6]

What can we say about the psyche-generating quantum field?

If one examines the phenomenology of the mind, we see that it is broadly composed of two genre of ideas, namely ideas, thoughts and concepts that are completely and purely individual's private preserve and need not have any validity for any other individual; for example, a person's preference for music, choice of reading material and so on. The other category of an individual's thoughts are those that have a more universal character; for example the proof of a mathematical theorem may be found by an individual, but the process of reasoning and the conclusions reached thereof can, in principle, be followed by all individuals, and represents the universal aspect of human consciousness.

A person's awareness of his own body would fall in the category of specific and individual state of the psyche that excludes all other persons, whereas the universal thoughts and ideas that are common to all of mankind would include all scientific and mathematical ideas.

Consequently, to describe the human psyche we need two kinds of quantum fields, namely one that refers to the specific individuality of the person, and which should be more or less localized with the person's specific existence and exclude others, and the other that represents the universality of the human psyche, and which can overlap and include other's consciousness. It is natural to represent the individualized state of the human psyche by a fermion field $\psi(t,x)$ and the universal character of human consciousness by a boson field $\phi(t,x)$, where t,x are time and space coordinates. These two fields ψ,ϕ are projections of a consciousness superfield denoted by

$$\begin{aligned}
&\Psi(t,x;\Theta) = \psi(t,x) + \Theta\phi(t,x)\\
&\psi(t,x): \text{ Individual centered consciousness field}\\
&\phi(t,x): \text{ Impersonal (general) consciousness field}
\end{aligned}$$

where Θ is an extension of space by a special kind of fermionic co-ordinate that we take to indicate realms of consciousness that are beyond the usual physical realm.

There are more features of the consciousness superfield that we need to represent. Note that the human psyche has various grades and stations that span the range from evil to good. Most individuals are in the mainstream of society, with some being below the average, and others such as saints and prophets who are above the average. Every individual has the potentiality in him or her to be a saint or a sinner, and what the person actualizes is in the final analysis the free choice of individual. A person moves between different stations and levels of perfection

[6]One of the authors [BEB] had constructed a simple model of consciousness as a quantum field theory in [8].

and imperfection, depending of the person's activities. The possibility of a person changing his state of being reflects the many internal states and levels of the psyche that are present in all individuals.

To represent these internal states of the human psyche, similar to the case in physics, the superfield is imparted internal non-Abelian symmetries, that in effect yield a whole collection of superfields – all related by symmetry transformations forming for example a Lie Group $\mathcal{G}$. Hence we write the consciousness superfield as

$$\Psi = T^a \Psi^a \ ; \ a = 1, 2, ...$$
$$[T^a, T^b] = i \sum_c C_c^{ab} T^c : \text{Lie Algebra}$$

The various superfields Ψ^a represent internal states of the human psyche that are qualitatively different, and their presence varies from person to person, depending on the knowledge of the individual as well as the individual's moral and social behaviour.

We are not yet done. Human psyche's interact with each other by exchanging ideas, concepts, thoughts on the one hand, and on the other hand by exchanging feelings and emotions that may not be articulated as ideas. The interactions of the human psyche are the result of the interactions that exist between the consciousness superfield at two different points of space and time. The analogy from physics is given by the interactions between electrons: the electrons at two different points interact with each other by creating disturbances in the photon field that they are coupled to. The photon field is a distinct entity that is the carrier and mediator of interactions between electrons. Reasoning by analogy, we postulate a vector superfield $\mathbf{V}$ that is coupled to the consciousness superfield Ψ, and mediates the interaction between individual psyche. The vector superfield $\mathbf{V}$ has bosonic and fermionic components similar to the psychic superfield Ψ. All communications between individual psyches – both those that are articulated and those that are not – are mediated by the vector superfield $\mathbf{V}$.

In summary, in our quantum model of the human psyche, an individual's psyche is the expression of underlying global quantum fields that span the entire universe, namely the consciousness superfield Ψ interacting via the vector superfield $\mathbf{V}$.

As we mentioned earlier, a metaphor for an individual human psyche is a wave that is created in the underlying ocean of the universal consciousness superfield. Hence, to create an individual human psyche, we first need to represent the quiescent 'ocean' on which the individual psyches will appear as waves.

7 Dynamics of the Consciousness Superfield

Similar to the case of the electron quantum field, we need to define how the consciousness superfield evolves in time, as this has far reaching consequences for the structure and evolution of an individual's psyche. The energetics and structure of a quantum field are defined by what is called the 'Action', namely $A[\Psi, \mathbf{V}]$, which is a functional of the two superfields; the action $A[\Psi, \mathbf{V}]$ is a result of the energy of the various configurations of the superfields. The action could be supersymmetric, or could break supersymmetry depending on which form of Reality exists in the Universe.

Similar to the case of an individual psyche that is described by states that are elements of a Hilbert space $\mathcal{P}$, the global superfields $\Psi, \mathbf{V}$ also have states that describe their universal state, and the collection of all the states of the superfields form a huge Hilbert space of states for the

superfields, which we denote by $\mathcal{S}$. The individual states of the human psyche are also states of the quantum superfield, and the state space of an individual, namely $\mathcal{P}$, is a (small) subspace of the Hilbert space $\mathcal{S}$, that is $\mathcal{P} \subset \mathcal{S}$. The Hilbert space of any number N of individuals are spanned by the N- fold tensor product $\mathcal{P} \otimes \mathcal{P} \otimes .... \otimes \mathcal{P} \subset \mathcal{S}$.

There is a special state of the Hilbert space of the superfield that has the lowest possible energy allowed for the superfield, and this state is called the vacuum state of the quantum field, and is usually denoted by $|\Omega >$. The vacuum state corresponds to the undisturbed state of the quantum field which we earlier metaphorically referred to as an ocean. The vacuum is the 'quiescent' lowest energy state of the ocean.

Localized excitations of the consciousness superfield Ψ are created by 'creation' operators acting on the vacuum state $|\Omega >$, which we denote by a composite symbol $a^{\dagger}(t,x)$, and the 'destruction' of consciousness is denoted by $a(t,x)$. [7] The universal vacuum state is defined by the absence of any form of particular consciousness, which in equations is written as

$$a(t,x)|\Omega >= 0 \tag{10}$$

What is our interpretation of the vacuum state $|\Omega >$? It contains the seeds of all possible forms of subjectivity and consciousness that can exist in the Universe – be it human consciousness, or the consciousness of animals, or that of other alien species in some other galaxy. It is the state of possibility of all the psychic qualities and attributes of the Universe, all the laws and theoretical superstructure of the physical Universe.

We can start our representation of the psyche of one, or N- individuals, located at different points x_i, and at time t_i, by the following

$$|P(t,x) >= a^{\dagger}(t,x)|\Omega > \tag{11}$$

Many psyche's, located at points $t_1, x_1; t_2, x_2; ...t_N, x_N$ can be represented as

$$|P_1(t_1,x_1), P_2(t_2,x_2), P_3(t_3,x_3)...P_N(t_N,x_N) >= a^{\dagger}(t_1,x_1)a^{\dagger}(t_2,x_2)a^{\dagger}(t_3,x_3)...a^{\dagger}(t_N,x_N)|\Omega >$$

If we base the analysis of the allowed states of the human consciousness on the representation of the human psyche given above in eq.11, one can show that for interactions mediated by the vector superfield $\mathbf{V}$, a whole array of **bound states** of the human psyche with each other can be formed. For some special cases of non-Abelian symmetry of the superfield, we can identify male and female psyche with certain 'charges' that can be assigned to the states of the superfield, with say the plus charge being assigned to males (analogous to a 'particle') and negative charge being assigned to women (analogous to an 'anti-particle'). Bound states of a male and a female emerges naturally due to the interaction being mediated by a vector superfield. For the Lie Group of symmetries that is given by $\mathcal{G} = SU(3)$, bound states of only three or more can be formed of all males or of all females.

8 The Human Species Ground State

There are a number of shortcomings of the representation for human psyche given in eq.11. We know, for example, that an individual's consciousness and psyche is the result of socialization,

[7] For notational simplicity we have suppressed all non-Abelian and spinor structure for the creation and destruction operators. The states created by the quantum superfield $\mathbf{V}$ enter in a more complete representation of the human psyche.

and is **grounded** on an immense pre-existing theoretical structure – such as language, culture, information and so on – that are fundamental to the formation of an individual's consciousness. The vacuum state $|\Omega>$ of the quantum superfield, from which we are creating an individual's consciousness in eq.11, is a global state spanning the entire universe, with no reference to human beings or to the specific history and evolution of human consciousness.

We need to define the 'ground state', represented by the state vector $|G(T)>\in \mathcal{S}$, on which the consciousness of the human species 'stands' at time T of human evolution. We postulate that the ground of all forms of human consciousness, at a particular instant t, is the result of the subjective life of all human beings who have lived before time t. Prophets, saints, artists, leaders, scientists and so on clearly should be weighed more in the structure of the species ground state that those individuals who have had little impact on the general human condition. Hence, the contribution of different individuals should be weighed according to the importance of their contribution to the formation of human consciousness.

To make the representation more transparent, consider the 'first' human beings, namely 'Adam' and 'Eve'. For Adam the ground state $|G(T)>$ would be almost identical to the vacuum state $|\Omega>$.[8] The psyche of Adam would be represented as in eq.11. The contribution of Adam to the ground state, during the interval of time $[t, t+\varepsilon]$, will be given by the action on the vacuum state of the operator:

$$U_{\rm Adam}(t,\varepsilon) = 1 + \varepsilon\mu_1(t, x_1(t))a^\dagger_{\rm Adam}(t, x_1(t)) \tag{12}$$

where $x_1(t)$ is the path followed in space by Adam at time t and $\mu_1(t, x_1(t))$ the weight attached to him at time t. At the same time, the contribution of Eve to the ground state, during the interval of time $[t, t+\varepsilon]$, will be given by the action on the vacuum state of the operator:

$$U_{\rm Eve}(t,\varepsilon) = 1 + \varepsilon\mu_2(t, x_2(t))a^\dagger_{\rm Eve}(t, x_2(t)) \tag{13}$$

So for the generation that came after Adam and Eve, we can represent the ground state by

$$|G(100\ \text{years})>= \prod_{\rm t=0}^{100\ \rm years} {\rm U_{Eve}(t,\varepsilon)U_{Adam}(t,\varepsilon)}|\Omega> \tag{14}$$

where, for simplicity, we have assumed that both Adam and Eve lived for a 100 years following paths in space given by $x_1(t), x_2(t)$, and that only the two of them affected the consciousness ground state for the next generation.

Note that the operators $U_{\rm Adam}(t,\varepsilon)$ and $U_{\rm Eve}(t,\varepsilon)$ symbolize the exponentiation of the creation operators associated to Adam and Eve.

To mathematically represent the ground state $|G>$ in full generality we need some notation. Let $N(t)$ be the number of persons who have lived up to time t, and let n label a particular human being who followed a particular physical path $x_n(t)$ during his or her lifetime; we choose the origin of time $t=0$ from the point of real time at which human consciousness emerged on the earth. We can then write the human ground state as

$$|G(T)>= T[\prod_{t=0}^{T}\prod_{n=1}^{N(t)} U_n(t,\varepsilon)]|\Omega> \tag{15}$$

[8]The vacuum state of consciousness is affected by all forms of consciousness that emerged on earth before the advent of human consciousness and hence altered $|\Omega>$, but we ignore these for simplicity.

where $U_n(t,\varepsilon)$ is the analogue of $U_{\rm Adam}(t,\varepsilon)$ given by eq.12 but for the particular human being labelled by n. For the product of operators, the time ordering symbol $T[..]$ means that the earlier times should be placed on the right, and the later times consequently should be on the left hand side. Operators $U_n(t,\varepsilon)$ contain functions $\mu_n(t,x_n(t))$ which are the weights attached to the individual n, and that vary during his lifetime.

Given that the population of the human species has been growing exponentially since the last few centuries starting at time denoted by t_0, we approximately have that $N(t) \simeq e^{\lambda(t-t_0)}N_0$. Hence on an exponentially increasing product of operators given by $|G(T)>$ it is more and more unlikely that any individual consciousness can change the ground state in a dramatic manner; rather it seems that the coherent and organized effect of millions of psyche is more likely to have a significant impact on $|G(T)>$.

The ground state $|G(T)>$ represents the sum total of all the excitations of the vacuum state $|\Omega>$ of the consciousness superfield that has been effected by human subjectivity over the entire period of human evolution. It is on this ground that the present day psyche of human beings is standing, and the entire theoretical superstructure that we are born into is encoded in the ground state $|G(T)>=|G>$, where T stands for our contemporary time. The species ground state contains the sum total of human subjectivity, and includes language, culture, historical identity, religions, mythologies and folklore of the past, the theories of science, and all such human creations that have left a lasting impact on human consciousness.

The individual human psyche, located at time t and at position x can be represented as

$$|P>\equiv |P(t,x(t))>\simeq a^\dagger(t,x(t))|G(t)> \tag{16}$$

We will refine this representation of an individual's psyche in the next section.

Using symmetry principles, for $\mathcal{G}=SU(3)$, one could show that bound states of the psyche of a male and a female still exist for psyche $|P>$ created from the ground state $|G>$, as well as the triplets (or more) of all males and females . One could explore other symmetry groups G to see what other forms of bound states for human psyche can be formed.

The human psyche is one form of excitation of the consciousness superfield. In terms of the psychic 'energy' required to create a human psyche from $|G>$, the human psyche is probably a very high energy state, given that $|G>$ is already energetically well above the vacuum energy. One may question as to how are the consciousness superfields coupled to the quantum fields of the physical universe. Just as one needs to infuse energy into physical fields to excite them, the biophysical structure of the human brain may be the physical means of coupling the consciousness superfield to the body of a human being. Moreover, other animals like monkeys, dogs, cats and so on might have sufficiently complex biophysical structures to energize the lower psychic energy states of the consciousness quantum field, explaining the rudiments of consciousness that these animals display.

Complex ideas about Reality, both physical and spiritual, might be very 'energetic' states of the consciousness superfield – similar to the Sun being a high energy state in the physical universe – and could explain the mentally illuminating power these ideas have.

8.1 Quantum Model for Consciousness and Self-Consciousness

In quantum mechanics we have a rather unexpected representation of the consciousness and self-consciousness dialectic [8]. Since the 'object' of self consciousness is consciousness itself, the human psyche can be **either** in the state of consciousness **or** in a state of self-consciousness in which it is viewing its own consciousness. A psychic state corresponds to an operator $a^\dagger$

– as expressed in eq.11. The fact that the human psyche cannot simultaneously be in both states leads us to identify consciousness and self consciousness with canonically conjugate and non-commuting operators.

We hence identify $a^\dagger$ with consciousness and **rate of change** of consciousness with self-consciousness. Note that the rate of change of a particular consciousness is a subjective construct, with some individuals having a very high rate of subjective change compared to others. We denote the subjective and psychological time of an individual by t_I, which is some function of physical time. Self consciousness can then be defined as the state created by the following operator, namely

$$\frac{\partial a^\dagger}{\partial t_I} = \frac{\partial t}{\partial t_I}\frac{\partial a^\dagger}{\partial t} \tag{17}$$

These two operators $a^\dagger, \partial a^\dagger/\partial t$ are canonical conjugate operators, namely $\partial a^\dagger/\partial t$ does not commute with $a^\dagger$, which is the essence of the Heisenberg Uncertainty Principle. The fact that we cannot simultaneously be in the state of consciousness and self-consciousness is reflected in the fact that $[\partial a^\dagger/\partial t, a^\dagger] \propto \hbar \neq 0$.

Hence we see that, in the quantum theory of consciousness, it is only due to the Heisenberg Uncertainty Principle that self-consciousness is differentiated from consciousness.

9 A Particular Human Psyche

Every person considers his psyche as a private entity that is the sole preserve of only his own subjectivity. From the construction of the human psyche from an underlying consciousness superfield, it is clear that no individual psyche can be considered in isolation from the rest of the human species. Nevertheless, for simplicity, and to reflect the fact that to a good approximation every individual seems to constitute an independent and integral entity, we start our analysis of the human psyche by considering a particular individual psyche in isolation, and only in later will we discuss the essentially social nature of an individual's psyche.

From eq.16 we see that an individual's psyche is a disturbance on the underlying 'ocean' of the species ground state $|G>$. From his birth, a person acts on the species ground state to actualize his own psyche. Since the effect caused by most individuals on $|G>$ is limited to his own self and those of his family – with little impact on society as a whole – to a good approximation we consider that part of the ground state that is directly acted upon by an individual to be $|G_{\text{Individual}}>$.

To construct $|G_{\text{Individual}}>$ note that the formative years of most individuals is deeply affected by his parents – and the extended family in general – in the earlier stages of his life, and only when he is a mature adult does he interact independently with society at large. Hence the individual's ground state can be modelled as the following. Suppose the individual is taken to be mature by the time he is 20 years old; till this time, the individual's psyche has access to the species' ground state only through the filter provided by his parents. We define the **effective**

ground state on which the individual's psyche acts as [9]

$$|G_{\text{Effective}}(t)>=\begin{cases} U_{\text{Mother}}(t,\varepsilon)U_{\text{Father}}(t,\varepsilon)|G(t)> & t<20 \text{ years} \\ |G(t)> & t>20 \text{ years} \end{cases} \tag{18}$$

where $U_{\text{Mother}}(t,\varepsilon)$ and $U_{\text{Father}}(t,\varepsilon)$ are the analogues of the operators $U_{\text{Eve}}(t,\varepsilon)$ and $U_{\text{Adam}}(t,\varepsilon)$ given by equations 13 and 12, respectively for the mother and the father.

The individual's ground state is generated by the action of the person's psyche on the effective ground state over his lifetime, and is given

$$|G_{\text{Individual}}(t)>=\prod_{t_{\text{Birth}}\leq t'<t} a^{\dagger}_{\text{Individual}}(t',x_{\text{Individual}}(t'))|G_{\text{Effective}}(t')>$$

To the leading approximation, an individual's psyche is generated by the individual's mental action on his own ground state $|G_{\text{Individual}}(t)>$. We hence have that the psyche of an individual is given by

$$|P(t,x(t))>=a^{\dagger}_{\text{Individual}}(t,x_{\text{Individual}}(t))|G_{\text{Individual}}(t)> \tag{19}$$

9.1 Human Essence

Where does the ground state $|G_{\text{Individual}}>$ reside in the human psyche?[10] What is its significance?

Part of it is in the conscious waking state, as is the case with language, and part of it is something that we may not be aware of consciously, and can be said to be an unconscious substratum of the human psyche that many thinkers have propounded. If one self-consciously reflects on one's own psyche, then one can gauge some of the elements that are accessible to conscious recall; maybe on further effort, other 'hidden' facts about one own ground state can become accessible to conscious recall. Since self-analysis and conscious recall are in the domain of self-consciousness, we postulate that the parts of one's own ground state that is amenable to conscious recall, which we label by the state |Accessible to Consciousness >, are the memories of an individual that can be consciously recalled. We associate the recalling of memories, and self-reflection in general with the process of self-consciousness, and hence postulate that

$$|\text{Accessible to Waking State}>=\frac{\partial \text{a}^{\dagger}}{\partial \text{t}_{\text{I}}}|\text{G}_{\text{Individual}}> \tag{20}$$

We hence have the following decomposition of an individual's ground state

$$\begin{aligned} |G_{\text{Individual}}> &= |\text{Accessible to Waking State}>+|\text{Inaccessible to Waking State}> \\ &\equiv |\text{Memory states}>+|\text{Unconscious}> \end{aligned}$$

Since we have excluded the ground state from both the sleeping state and the waking state – one can only be aware of psychic events that are excitations on the individual's ground state – we need to give an interpretation of $|G_{\text{Individual}}>$. Note since both the waking and sleeping

[9] In principle, one can include the entire family tree in the preparation of an individual's ground state; for a more accurate construction, all those who have interaction in person with the individual should be included in the preparation of an individuals ground state, including all the siblings, the grandparents and uncles and aunts and first cousins and so on.

[10] We suppress the time index for $|G_{\text{Individual}}>$ in this section.

states are excitations of $|G_{\text{Individual}}>$, the very nature of the excitations of waking and sleeping state, and its range and scope, reflect features of $|G_{\text{Individual}}>$; for example waves on an inland lake are different from the waves on a salty ocean. Hence $|G_{\text{Individual}}>$ permeates both the waking and sleeping state and we consider it to be the ground of an individual's psyche.

In this sense, the ground state $|G_{\text{Individual}}>$ can be said to be close to the essential structure of a person's psyche, and hence we call it the **essence** of the person.

10 Waking and Sleeping States

At the most basic level, consciousness is linked to the state of the body, namely a person can be awake or can be sleeping, or in a state in-between the two. Since the person may not necessarily be completely awake or completely asleep, we need to represent the psyche as an 'admixture' of the sleeping and the awake state. We first discuss sleeping and waking states by themselves, and will then address the question of how the psyche is constituted out of these.

10.1 Waking State

Consider the state of a person who is awake. A person can bring a thought to his conscious mind either by recalling a pre-existing thought (say the name of a friend) or by creating a brand new thought, for example, the name of a new road he is on. The individual's ability to create and remove (destroy) thoughts from the conscious state of his mind can be represented, similar to the case of creating a complete psyche out of the ground state $|G>$, by creation and destruction operators that exist only at the command of a particular individual, and which we label by $c^\dagger$ and c respectively. The mental excitations of an individual's psyche are low 'energy' excitations of the psychic field and the creation and destruction operators create the low energy excitations of this field.

Again, similar to the case of the definition of the vacuum state given in eq.10, an individual psyche in its own ground state has no excitations (no thoughts), and hence

$$c|G_{\text{Individual}}>= 0 \tag{21}$$

To quantify how an individual psyche creates ideas and thoughts inside its mind, we postulate that we can assign a 'psychic energy' to all the ideas in a person's mind. Minor and mechanistic thoughts for an adult, such as pouring out a glass of water or recalling the multiplication table, require little mental effort and can be said to have low amounts of psychic energy. Ideas exist as integral entities; there is no such thing as 'half an idea'; an idea either has an integral reality, or does not exist. Following the quantum principle that energy comes in discrete packets with a minimum energy ϵ, we postulate that all the conscious thoughts that an individual has, or can be trained to have, have an integral multiple of ϵ, and a particular idea, labelled |Idea(n) >, has a discrete psychic energy of $n\epsilon$, reflecting that it is an integral quantum of an idea. We then have, from quantum theory, that

$$\text{Idea(n)} >= [\text{c}^\dagger]^{\text{n}}|\text{G}_{\text{Individual}} > \tag{22}$$

Many ideas can have the same amount of psychic energy, and hence this classification is highly degenerate; a more detailed and refined analysis is required to distinguish the space of ideas more closely.

Let us assume that the earlier superposed state of the individual's psyche that we wrote in eq.5 is the result of acting on the individual's ground state n-times; we can then represent the awake state of the human psyche as

$$|a>= c(1)[c^\dagger]|G_{\text{Individual}}> +c(2)[c^\dagger]^2|G_{\text{Individual}}> +...c(N)[c^\dagger]^N|G_{\text{Individual}}> \tag{23}$$

10.2 Sleeping State

How should we represent the sleeping state of an individual? From physiological studies of the brain during its sleeping state, it is known that the brain is as active in the sleeping state as it is in the awake state. Moreover, the mind experiences a myriad of phantasmagoric world of dreams and of imaginary events. The creation of the sleeping state of the human mind does not proceed along the same lines as that of the waking mind, which consciously creates and manipulates ideas. Instead, the sleeping mind generates dreams and dreamless sleep almost spontaneously, perhaps dominated by biophysical and other agents. It is the same human psyche that sleeps and awakens, and so is grounded on the same individual ground state $|G_{\text{Individual}}>$.

We represent the difference between the waking and sleeping state by postulating that there is another set of creation and destruction operators – separate from the waking state operators $c^\dagger, c$, that create the sleeping state (including dreams and dreamless sleep) labelled by $b^\dagger, b$.[11] Similar to the case for the waking state, we have for the individual's ground state

$$b|G_{\text{Individual}}>= 0 \tag{24}$$

A sleeping state is then represented, similar to eq.23, by

$$|s>= b(1)[b^\dagger]|G_{\text{Individual}}> +b(2)[b^\dagger]^2|G_{\text{Individual}}> +...b(N)[b^\dagger]^N|G_{\text{Individual}}> \tag{25}$$

The main difference between the waking and sleeping state is that in the waking state a person can consciously apply the creation and destruction operators $c^\dagger, c$ to create and destroy ideas in response to either an external stimuli or by free will. In contrast, the application of operators $b^\dagger, b$ that create the various sleeping states of the individual's psyche are out of reach of the waking mind, and it is not clear who or what causes the application of these operators on $|G_{\text{Individual}}(t)>$.

One possible explanation of why dream states occur is that the person's ground state $|G_{\text{Individual}}(t)>$ depends on time; as the person experiences new states of the psyche during the waking state, the individual's ground state has an influx of new ideas, and this changes it. To maintain its property of the ground state that is annihilated by the operators c, b, the ground state needs to be re-diagonalized and this process would generate changes in consciousness that are experienced as dreams. The ground state re-diagonalizes itself continuously, but during the waking state these effects are over-shadowed by the waking state.

10.3 Combination of Waking and Sleeping States

Should the state of the psyche be a superposition of these two states: the awake state $|a>$, and the sleeping state $|s>$? The answer is no. The reason being that waking and sleeping are two qualitatively different states of the human psyche, in the former we can exert free will and

[11] According to Alain Connes the creation and destruction operators $b^\dagger, b$ can be thought of as the anti-particles of the waking state creation and destruction operators $c^\dagger, c$.

choose the thoughts we wish to engage in, whereas in the sleeping state we have no conscious control on what we dream. We hence need to **expand** the Hilbert space to accommodate the dreaming states, and write the composite state of the psyche as a **tensor product** of the waking and sleeping states. In symbols we tentatively have

$$|P> \simeq |a>|s> \tag{26}$$

We are not done yet. The expression for $|P>$ for the individual's psyche given above represents a state in which the waking and sleeping state are decoupled. We all know that there are circumstances when a dream is so 'strong' that one even wakes up disturbed and woken by the dream itself. It is quite common that students faced with exams often wake up from a dream in which they have missed the examination.

In general, if the dream comes into strong conflict with ideas held by the waking state, the dream tends to be remembered. From these facts, it is clear that the waking and sleeping states are not decoupled, but instead the state $|P>$ is a correlated combination of the waking and sleeping states. There is a special way in which a state can be a correlated combination of its constituents; it is called an entangled state in quantum mechanics. To illustrate how $|P>$ is constructed, suppose there are two waking states, namely $|a;t>$ which denotes taking the exam, and state $|a;m>$ which denotes missing the exam, and similarly, dream states $|s;t>, |s;m>$ which denote the person having a dream that he has taken or missed the exam, respectively. The following state

$$|P> = |a;\text{taken}>|\text{s};\text{missed}> + |\text{a};\text{missed}>|\text{s};\text{taken}> \tag{27}$$

is a candidate for the entanglement of the waking and sleeping states since there is discordance between taking the exam in the waking state and the dream of a missed exam and vice versa. On waking up from one of the two types of dream, the superposed state that the psyche is in, given in above equation, will be lost. One can say, in the language of quantum measurement theory, that the waking state has performed a measurement on the sleeping state.

In general, the psyche of a person can be represented as

$$|P> = \sum_{ij} \alpha_{ij} |a;i>|s;j> \tag{28}$$

where we label the various waking and sleeping states by indices i, j and coefficients α_{ij} specify how these states are entangled in the person's psyche.

11 Time Evolution of an Individual Psyche

The evolution in time of a human psyche, like any other quantum system, is determined by its psychic energy operator, called the Hamiltonian and denoted by $H(c, c^\dagger; b, b^\dagger)$. The Hamiltonian couples the waking and sleeping state operators, and hence a person's waking and sleeping states communicate with each other in the development and change of the individual's psyche.

As a human psyche evolves in time, it may enrich itself internally, as well as get more 'entangled' with other individuals as well as with the ground state $|G>$ and in principle even with the global vacuum state $|\Omega>$. To study the development of a human psyche in full generality is a formidable problem, requiring the full mathematics of supersymmetric quantum field theory.

A first approximation to studying the dynamics of an individual is to consider the internal evolution of a person and only its entanglement with the ground state $|G>$, and bring in its entanglement with other individuals as higher order terms.

The non-Abelian Lie Group $\mathcal{G}$ yields a multi-dimensional internal space for the evolution of a single individual. Every human being can choose his or her own destiny, and decide on the path to take in life; a person can also change at any point of one's life, specially where it concerns one's own private habits and state of mind. For example, a person can choose to become a drug addict, and another person can decide to break the addiction to drugs. These internal states of the human psyche are an everyday reality, and to explicate this aspect of the human psyche, let us label the individual's psyche by $|P;t>$. Let $\{|i>\}$ be a set of appropriate basis states that span the Lie Algebra of $\mathcal{G}$; then to a first approximation we have

$$|P;t>=\sum_{i=1}^{m} c_i(t)|i>$$

From eq.19

$$\begin{aligned} |P(t,x(t))> &= a^\dagger(t,x_I(t))|G_{\text{Individual}}(t)> \qquad (29)\\ \Rightarrow \frac{\partial}{\partial t_I}|P(t,x(t))> &= \frac{\partial a^\dagger(t,x_I(t))}{\partial t_I}|G_{\text{Individual}}> + a^\dagger(t,x_I(t))\frac{\partial}{\partial t_I}|G_{\text{Individual}}(t)> \end{aligned}$$

The evolution equation above is too complex to start our analysis, and we hence approximate the evolution of an individual's psyche by

$$\begin{aligned} \frac{\partial}{\partial t_I}|P(t,x(t))> &\simeq \sum_{i=1}^{m}\frac{\partial c_i(t)}{\partial t_I}|i>\\ \frac{\partial c_i(t)}{\partial t_I} &= \sum_{\alpha} H_i^\alpha c_\alpha(t) \end{aligned}$$

In our approximation, the Hamiltonian $H_i^\alpha = H_i^\alpha(c,c^\dagger;b,b^\dagger)$ is driving the evolution of the individual psyche. Suppose $|i=10>$ corresponds to a purified state; then it would be up to the free will of a person who wishes to purify his or her soul to **choose** the appropriate Hamiltonian H_i^α to achieve this end. For example, for a person breaking the addiction to drugs, a person's free will can choose to make some of the addictive and destructive elements of the Hamiltonian – that are perpetuating the addicted state – equal to zero, and hence evolve to a non-addicted state.

12 Human Psyche and its substructure: Entanglement

An individual is not an isolated and complete entity, given the many forms of relationships and networks that every individual is a part of. We now look at the 'many body' nature of the individual human psyche, and the fine features of an individuals psyche, its so called substructure, that results due to the individual's interactions with society.

The 'many body' structure of the human psyche and the representation of its substructure emerges from its model by a quantum superfield. From quantum field theory we know that if we probe an electron at a definite scale, we measure a definite electric charge and a definite mass for the electron, i.e. we probe a definite structure of the electron. If we change the scale of

the probe, for example if we probe the electron at a smaller scale, the measured electric charge and the measured mass of the electron will be different, i.e. the structure of the electron will be different. This is a consequence of the fact that in quantum field theory there is an effective theory for each scale.

Suppose one observes the electron at lengths always greater than say $l = 10^{-12}$cm. We will observe an effective electron state $|e(l) >$ in which all the effects of all the length scales shorter than l have been incorporated into the electron state $|e(l) >$.[12] Now suppose we observe the electron more closely, at distances larger than $l/10 = 10^{-13}$cm. What shall we see? Quantum field theory tells us that viewed from the smaller scale, the electron state $|e(l) >$ can be constructed from the electron state $|e(l/10) >$ [13]and other states which contain photons of energies up to a maximum energy corresponding to the scale $l/10$ and virtual electron-positron pairs. The transformation from the state $|e(l) >$ to the state $|e(l/10) >$ is mathematically accomplished by the Renormalization Group equation.

Let us make an analogy between this quantum structure of the electron and the structure of the human psyche. As a first approximation of the human psyche, if one observes a person in a crowd, say in a public bus, one observes a composite person who appears interchangeable with anyone else in the crowd, and can be represented by the psychic state $|P >$. The analogy with the electron is that we are performing a crude observation on the person.

One can probe more deeply into the psyche of the individual, and similar to the case of the electron, we will find that there is more substructure to the state $|P >$. We can represent the substructure of $|P >$ in the same manner as we did for the electron, except now we have to find the analogy for the states at a more fine scale for the person. The finer scale in the case of the psyche is given by the likes and dislikes of the person, his family , friends, his profession, his acquaintances and so on. To start with, the person has a psyche on a more refined scale given by the state $|P' >$, and this is the psyche that one would observe if one was meeting the person, not as a faceless member of a crowd, but rather at a dinner party or at some similar social occasion.

A person is known by the company he or she keeps, and this is also reflected in the state of the person's psyche. Suppose the person has a friend denoted by a state $|P_1 >$. Two individuals, two human beings can be entangled through their conscious and unconscious states. There is no absolute separation between the two psyche. Probing such an entangled structure by one of the two psyche, let us say by the consciousness of the psyche P, is to become aware of the underlying common values and views that are shared by the two individuals. A person and a friend can be said to form an entangled state $|P', P_1 >$.

Similar to our analysis of the waking and sleeping states, two persons, say $|P_a >$ and $|P_b >$ who are completely disconnected – for example two strangers in the bus – are represented as a product of their two states $|P_a > |P_b >$, and these states are called dis-entangled states. On the other hand, two states that cannot be factorized are called entangled states in quantum mechanics, and there are precise quantitative measures of the degree of entanglement of quantum states.

The main difference between a bound state and an entangled state is that for a bound state there needs to be continual interactions between the elements that are bound; for example, in the hydrogen atom the proton and electron are in a bound state due to continuous exchange of photons. In contrast, for an entangled state, even when the particles are far outside the range

[12]More precisely, every length scale l has its own effective Hamiltonian H_l whose energy eigenstate is given by $|e(l) >$.

[13]Length scale $l/10$ has its own effective Hamiltonian $H_{l/10}$ whose energy eigenstate is given by $|e(l/10) >$.

of any possible interaction between them, they continue to persist in globally correlated states, and the name 'entanglement' is given to such states.

Entangled states need to be prepared by using the interaction between the entangled constituents, but once this preparation is completed, the entanglement (correlation) continues to persist even in the absence of any interaction.

The analogy for the human psyche of a bound state is a nuclear family, where all the elements of a family are kept 'bound' together by constant interaction, be its emotional, financial, social interactions that arise due to living in the same household. The analogy of the entanglement between two individuals is for example the continuing bonds between children who are adults with their aging parents; for such a case there is no longer any common household, and no financial or other co-dependence; but entanglement can continue to exist over great distances and over many decades. The correlation between such apparently disconnected individuals is very well represented by the concept of the quantum entanglement of two or more psyche.

The preparation of an entangled state need not necessarily take a long time; the well known phenomenon of 'love at first sight' shows that there can be an almost instantaneous entanglement of two individuals, who continue to be 'in love' (correlated) even if they are subsequently separated – without any communication – for long periods of time.

The psyche at the coarse level can be represented by the same person's psyche at a more refined level as

$$|P>= c_0|P'> +c_1|P', P_1> \tag{30}$$

There may exist also an entangled state of individual P with yet another individual labelled as P_2, ... In this case we have to consider the following quantum superposition

$$|P>= c_0|P'> +c_1|P', P_1> +c_2|P', P_2> +.. \tag{31}$$

It is also possible to consider a triple entangled state involving three individuals $|P', P_1, P_2>$ and so on. In this case we will have the following quantum superposition

$$|P>= d_0|P'> +d_1|P', P_1> +d_2|P', P_2> +d_3|P', P_1, P_2> \tag{32}$$

There are other forms of entanglement that come from the effect of the ground state on the person's psyche. For example, the attachment to a race or nation or religion affects an individual through the ground state $|G>$, and in some circumstances can be strong enough to launch wars based on nationalism or race or religion. Entanglement with the species ground state $|G>$ can also be strong enough so that peace prevails over war.

By resolving a person's psyche in a more and more refined basis, we are in fact probing the inner structure, and the interactions, of the consciousness superfield Ψ as well as the ground state $|G>$ that the human species has evolved over the last few thousand years.

There are further refinements that need to be considered. The entanglement and interaction of a person with his friends and colleagues can be taken to be the system that the person is directly involved with. What about the millions of people with whom a person has no direct connection? How do they enter into the psychic world of an individual? Any interaction with strangers can be modelled as the interaction of a person with the environment, and the role of the environment in every person's live is of great importance.

The environment acts as an observer in the life of an individual, tending to decohere the superposed states of an individual. This may be a reason why some sensitive and creative persons like spiritual masters, artists, scientists and so on prefer to live in relative isolation as the carefully prepared superposed states of their psyche then have less of a likelihood of undergoing decoherence due to interactions with the environment.

13 Conclusions

We have proposed a quantum theory of consciousness, and applied it to represent and explain some of the key features of the observed phenomena that are displayed by human consciousness.

A few key assumptions that have been made in this article can be addressed empirically. The most important of these being to provide experimental evidence that the mind in fact can be in a superposed state. Another key concept that needs to be studied further is how two human psyche become entangled, and if there are any measurable quantities that can provide evidence for this entanglement.

The analysis of the waking and sleeping states using the concepts of quantum mechanics needs to be further developed to provide a more detailed explanation and interpretation of dreams.

The larger question of how the collective consciousness (and unconsciousness) emerges from the quantum field theory of consciousness is similar to the phenomenon of cooperative behaviour in physical systems, and needs to be studied.

And lastly, the psychic quantum field extends over the entire universe, and one can study if there are any 'global' oscillations of the supersymmetric vector field, similar to the excitations of the physical electromagnetic field that reach us from distant galaxies.

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References

[1] R. Penrose, *Shadows of the Mind*. Oxford, UK: Oxford University Press (1994)

[2] S. A. Klein, *Is Quantum Mechanics Relevant To Understanding Consciousness?* PSYCHE,2(3), April 1995

[3] B. J. Baars, *Can Physics Provide a Theory of Consciousness?* PSYCHE,2(8), May 1995

[4] W. Pauli, C. G. Jung, "Correspondance 1932-1958", Bibliothèque Albin Michel Sciences

[5] J. von Neumann, *Mathematical Foundations of Quantum Mechanics*, Princeton: Princeton University Press (1955)

[6] E. P. Wigner, Remarks on the mind-body question. Reprinted in Wheeler and Zurek, eds., *Quantum Theory and Measurement*. Princeton: Princeton University Press.

[7] H. P. Stapp, *Mind, Matter and Quantum Mechanics*. Berlin: Springer-Verlag.

[8] Belal E. Baaquie, *"Quantum Field Theory as a Model of Consciousness"* (1987), unpublished