Founding quantum theory on the basis of consciousness

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In the present work, quantum theory is founded on the framework of consciousness, in contrast to earlier suggestions that consciousness might be understood starting from quantum theory. The notion of streams of consciousness, usually restricted to conscious beings, is extended to the notion of a Universal/Global stream of conscious flow of ordered events. The streams of conscious events which we experience constitute sub-streams of the Universal stream. Our postulated ontological character of consciousness also consists of an operator which acts on a state of potential consciousness to create or modify the likelihoods for later events to occur and become part of the Universal conscious flow. A generalized process of measurement-perception is introduced, where the operation of consciousness brings into existence, from a state of potentiality, the event in consciousness. This is mathematically represented by (a) an operator acting on the state of potential-consciousness before an actual event arises in consciousness and (b) the reflecting of the result of this operation back onto the state of potential-consciousness for comparison in order for the event to arise in consciousness. Beginning from our postulated ontology that consciousness is primary and from the most elementary conscious contents, such as perception of periodic change and motion, quantum theory follows naturally as the description of the conscious experience.

KEY WORDS: Consciousness; quantum theory; measurement, EPR paradox.

1 INTRODUCTION

Quantum theory is plagued with conceptual difficulties such as the question of the so-called wave-function collapse in the measurement process [1], and the well-known paradoxes [1] [2] [3] [4]. While the literature addressing various issues of the interpretations of quantum mechanics [6] [5] [7] [8] [9] is rather rich [1] [11] [10] [12] [13], in this paper we will limit ourselves to mention those more directly related to the point of view elaborated here. Independently Schrödinger [14] [15], Wigner [16], Von Neumann [17], London and Bauer [18], and Pauli [19] have considered the possibility that consciousness plays a fundamental role in the interpretation of quantum
mechanics, especially in the question of measurement.

While in the so-called Copenhagen interpretation\cite{5} as well as in other interpretations the observer enters in a fundamental manner, ultimately, the nature of the observer is objectified and is considered to be the same as the instrument which carries out the measurement. On the other hand, the paradoxes and the problems associated with the process of the wave function collapse and the process of measurement have led many of the pioneers of quantum theory to examine the possible role of consciousness in the process of measurement. For example, Schrödinger in his “Tarnér Lectures” at the Trinity College (see “Mind and Matter” second part in Ref.\cite{14}, Chapters 1-4) discusses the fundamental role of consciousness and the role of the process of objectivation in the description of nature. Von Neumann\cite{17}, using projection operators and density matrices as tools to describe the apparent statistical character of measurement, was able to show that the assumed boundary separating the observing instrument and the so-called observed object can be arbitrarily shifted and, therefore, ultimately the observer becomes the “abstract ego” (in Von Neumann’s terms) of the observer. Similarly, London and Bauer\cite{18} followed a similar scheme to conclude that it is the “creative action of consciousness” by which “the observer establishes his own framework of objectivity and acquires a new piece of information about the object in question”. According to London and Bauer\cite{18} this leads to the collapse, namely to the choice of a particular state from a linear combination of the correlated states describing the combined system, i.e., the instrument and the observed object. Similarly Wigner\cite{16} proposes that inanimate or unconscious matter evolves deterministically according to the quantum mechanical evolution operator and when consciousness operates on inanimate matter, the result is the familiar projection process of measurement. Pauli and Jung\cite{19} through several letters and communications have discussed a parallelism between the operation of consciousness and quantum theory. Some of the philosophical ideas, from which we use in the present paper, can be also found in the books of Schrödinger\cite{14, 15} and they are extensively discussed in the next section.

In this paper quantum theory (more generally, the description of nature) is founded on the framework of the operation and on the primary ontological character of consciousness, rather than founding consciousness on the laws of physics\cite{12, 13, 20, 21}. It is discussed that quantum theory follows naturally by starting from how consciousness operates upon a state of potential consciousness and more generally how it relates to the emergence or manifestation and our experience of matter. In addition, it is argued that the problem of measurement and the paradoxes of quantum theory arise due to our poor understanding of the nature and the operation of consciousness.

2 CONSCIOUSNESS AND ITS OPERATION

We begin by introducing our concepts such as, streams of consciousness (particular and Universal), potential consciousness, and operation of consciousness which are necessary in order to discuss our ontological proposal.
2.1 Streams and Sub-Streams of Consciousness

The word consciousness usually means “experienced awareness”. A person is “con-
scious” or “has” consciousness if he is experiencing a “flow” of conscious events. The stream of consciousness consists of the conscious events that constitute this stream. The order or the sequence of these events gives rise to a temporal order which together with the experience of temporal continuity\[22\], as we will discuss later, introduce the concept of continuous time used in physics to describe the laws of nature. The contents of the stream, i.e., the conscious events, act to modify the tendencies for later events to enter the stream. The subject is either the holder or the experiencer of this “flow” of events or just this “flow” of entangled events.

First, we conjecture that all human beings and the other living organisms have their own streams of consciousness. In order to gain an understanding of all of these related streams of consciousness together, and what precedes our human thoughts, and binds them together, we postulate the existence of the Universal/Global stream of consciousness, as the primary reality that contains all of our individual streams, (which are sub-streams of the Universal conscious flow of events) and also conscious events that are not members of any human stream, but are like certain of our conscious events (to be clarified in later subsections). Note that the set of conscious events in consciousness must include all those that anyone has ever had, and for any personal stream of consciousness, all the events that have appeared in that person’s stream of consciousness.

Even though all of our thoughts and experiences are in our stream of consciousness, and have certain “feel” or quale, it is common and useful to draw some distinctions between different kinds of thoughts. While both are parts of our stream of consciousness, experiences through the sensory apparatus, or sense data, are distinguished from theoretical constructs where memory is a contributing factor in causing these events. Therefore, when we distinguish between “mind” and “matter” we are referring to the previously mentioned distinction. “Mind” refers to our conscious experience of the process of thought, whereas “matter” refers to the conscious experience of an imagined set of properties that are imagined to exist “when no one is looking”. A simple example of the latter is the experience of a surface, which, under microscopic examination, the imagined notion of surface disappears and is replaced by another imagined notion of an array of relatively widely spaced atoms or molecules. We are not denying the existence of something that causes these experiences and it persists when “no one is looking”. Instead we are only questioning its “substantial nature” and we postulate that these properties exist in the Universal Mind, namely, they are parts of the Universal stream of consciousness. The emergence of “matter” is discussed in Sec. 2.4

2.2 Intuition and State of Potential Consciousness

We postulate that a fundamentally new experience or an insight into a problem can occur through the intuitive character of the mind (or consciousness). Aristotle speaks of intuition which is only a “possibility of knowing without in any respect
already possessing the knowledge to be acquired.” The conscious event of a new experience or of the insight, while after it happens it can be rationalized, prior to its occurrence it can not be rationally inferred from the previous experiences alone. After such an event becomes part of the individual’s stream of consciousness, it can be incorporated into reasoning by assigning the experienced conscious meaning of it or qualia. This can be demonstrated by the fact that we cannot use reason to directly explain the experience of color to someone born-blind or any experience to one who never had this particular experience. Spinoza clearly states that reasoned conviction is no help to intuitive knowledge and Whitehead accepts that “all knowledge is derived from and verified by, direct intuitive observation.” Jung defines intuition as “that psychological function which transmits perception in an unconscious way.”

While the earlier sequence of events in a child’s stream of consciousness might be prerequisites for any new experience which causes the child’s further development, the new experience cannot be grasped in terms of the previous experiences alone. The same argument seems to be valid in the process of the evolution of species or of life in general. In order to describe such a process of fundamentally new conscious events, we find it necessary to introduce the notion of potential consciousness. Namely, in order to explain the manifestation of the experience and its tendency for re-occurrence after its first manifestation, we conjecture the existence of the potentiality for such a manifestation. When the experience fades from the stream of consciousness, we conjecture that, with respect to such an experienced quality, the state of consciousness is transformed into its potential state again with a modified potential for re-occurrence of this particular “felt-quality” in a future conscious event.

In the case where the intuitive mind is constrained in such a way that a fundamentally new experience (or intuition) is not allowed to occur, the state of potential consciousness is still necessary in order to describe what happens. One of the capabilities of human consciousness is to imagine what some future conscious event might be, and pre-ascribe values and likelihoods to these future possibilities. In this case the sequence of events along with their character and conscious qualia form the basis on which the state of potential consciousness is defined, namely, the potential for a particular future event to occur depends on the contents of consciousness accumulated during the previous events leading to the present.

We also ascribe to the Universal consciousness a Universal state of potential consciousness out of which an event can arise in the Universal stream of consciousness. Namely, just as the entire history of events which form the stream of consciousness in an individual and have causal consequences on what can happen in the present time or in the future time, in the same sense the contents of the Universal consciousness and their temporal order along with the operation of consciousness could entail evolution, unless a higher-level operation of consciousness intervenes. The operation of consciousness and its hierarchical structure is discussed in the following subsections.

Therefore, we postulate the primary ontological status, the oneness, and the universality of consciousness. The term “oneness” means that
there is only one stream of conscious flow with various sub-streams, the individual streams of consciousness, such as those which we are experiencing as human beings, but they are all connected to one Universal conscious flow. There is a hierarchical tree-like structure of this “branching” of the conscious flow as can be also evidenced within the human body. While there is a vast number of sub-streams deriving from the Universal consciousness, they all belong to the same single unbroken flow. This separation though between Universal and individual consciousness or streams of consciousness is done to facilitate the description of our experience and there is no sharp boundary, namely, the individual consciousness is a sub-stream of the Universal consciousness.

As it is discussed next, consciousness also acts on its state of potential consciousness in order to cause an alteration or change of the state in order to cause an experience. Finally consciousness has also the faculty of the experiencer, namely, the felt qualities or qualia or the objects which appear through the process of perception or measurement, a process which can take place at the level of the particular sub-stream or at a lower- or higher-level sub-stream of the Universal flow of consciousness. These notions are elaborated in the following three subsections.

2.3 The Operation of Consciousness

In our theory, consciousness also plays an active role and next we give an outline of the main functions of consciousness which are further discussed in the following sections.

As discussed earlier we postulate that the ontological character of consciousness is primary. The world “outside”, which is perceived by consciousness as objective, becomes actual through the operation of consciousness. Can one describe the state of any part of nature before the operation of consciousness? Let us call this state of nature before the operation of consciousness, “pro-nature”? Our language, our mathematics, our process of thought, our experience, is based on concepts (or percepts) which are all contents of consciousness. We will use the term conscious-concept or conscious-percept to generally represent the conscious quale or felt experience (or simply percept). Let us ask ourselves the question, “how else can we describe something that is behind the conscious perception?”, namely, by avoiding the usage of any concepts or percepts, because they are all products of perception, i.e. of consciousness. Einstein taught us that even “time” and “space” (which were once believed to “stand out there” independently of us) exist, in a sense, dependent on the process of their perception and measurement and they have no meaning independently of that. In this paper, we take a phenomenological position, that this “pro-nature” is also an aspect of consciousness, namely, the best way to describe it and be free of contradiction is to call it by its potential aspect and that aspect is “potential to become conscious”. Therefore, the state of nature, before the application of consciousness, is a state of potential consciousness. In the previous subsection we discussed that from the state of potential consciousness and through the operation of consciousness on the state of potential consciousness, an actual event arises, and
enters the particular or Universal stream of conscious flow.

Consciousness can be realized as operation and as experience through perception as follows. First in order to describe the operation of consciousness at a particular level of the Universal stream, we need to divide the complete hierarchical set of operations in two sets as follows: (i) The operations which occur at a particular level which corresponds to a particular sub-stream of consciousness and (ii) the operations which occur at all other levels. Namely,

- (a) First, the operation of consciousness at all other levels can be thought of as an operation which causes the state of potential consciousness, which corresponds to a particular sub-stream, to change or evolve. This change or evolution of the state of potential consciousness and its relation to the perception of time, which is complementary to the perception of change, is discussed in Sec. 4.

- (b) The state of potential consciousness evolves and remains in potentiality until it is perceived or measured by consciousness’ appropriate “instrument” at the particular level or sub-stream of the conscious flow. When this happens, an event arises or is actualized in the particular sub-stream of consciousness from the state of potential consciousness.

Perception or an event in consciousness can only be actualized only if consciousness operationally projects or measures the experience or event as follows:

- Consciousness asks a question (inquiry) or perceives a change or alteration in its state of potential consciousness $|\psi_i\rangle$, by acting on the $|\psi_i\rangle$. The result of this operation, i.e., $|\psi_{i+1}\rangle = \hat{O}|\psi_i\rangle$ (here $\hat{O}$ represents the action of consciousness, through an operational question which in general causes a change), is evaluated by comparing the changed state of potential consciousness, i.e., $|\psi_{i+1}\rangle$ with the previous state of potential consciousness $|\psi_i\rangle$.

- This process of projection or objectivation creates an actual event in consciousness. Namely the event is manifested or it becomes a phenomenon or an object in consciousness through such an operation of consciousness.

Therefore, we postulate a sequence of pairs $\{|\psi_i\rangle, C_i\}$ consisting of a sequence of conscious events $C_i$ during each of which consciousness operates upon and changes the state of potential consciousness $|\psi_i\rangle$. The state $|\psi_i\rangle$ constitutes a set of potentialities out of which the next conscious event $C_{i+1}$ arise. Namely, the activities of our body/brain are not the causes of conscious events, they are consequences of conscious events.

Let us give a simple example of the operation of consciousness. The subjective experience of the sweet taste of a fruit. The fruit is not sweet unless it is tasted, namely, there is no sweet taste attached to the molecules of the fruit. Sweetness is a subjective experience; it is not a property of any interaction whatsoever of the
ingredients of the fruit with our mouth or with our nervous system. The result of this interaction is only a network of electromagnetic currents from the neurons of the body/brain. The same is true with any (subjective) experience. The word subjective is placed inside parentheses because all experience is subjective in the sense that only when it leads to such subjective qualia, it is experienced. It appears through the process of objectivation\[37\] that while “our hands” (including man-made instruments, our eyes, the nerves carrying the signal to the cortex, etc) act on the state of “nature”, what we actually “see”, is the conscious experience, the event in consciousness and this is what we must describe.

The question, “is this fruit sweet between observations of its sweetness?”, is a meaningless question. The correct question to ask is: “Is this fruit potentially sweet?” or even better: “What is the likelihood for this fruit to be found sweet when it is tasted?”. Clearly, the experience brings into existence, in consciousness, the taste from potentiality[28].

Therefore, in general, when an event occurs, an observable takes a definite value in consciousness from the state of the potentially conscious. The value has only meaning with respect to a measure, an ideal, an observable quality (in the example given before the measure is the taste and its value or its quality that of sweet) acquired by the operation of consciousness. If consciousness does not operate because the conscious attention is not there (for example someone’s attention is not in what he is eating but elsewhere), there is no event in “one’s consciousness” (in the particular sub-stream). When consciousness operates through one’s attention, only then the operated state of potential consciousness is compared to consciousness’ previous state. This is the process by which an event arises in consciousness.

Next, we would like to give an example to clarify why consciousness needs to compare the state obtained after the operational application of the measure or a question on the state of potential consciousness to its own previous state of potential consciousness. Suppose that we enter a room for the first time where an event took place before our entrance; we may not be able to figure out what the event was; however, a person who is “aware” of the state of the room before the event is able to find out what happened, by a mere comparison of the state of the room before and after the event. In the same way, consciousness is aware of its state of potential consciousness before the specific observation, which takes place by altering the state of consciousness by the operation of the examination of its state operationally and then comparing the new state with the old state of potential consciousness. Namely, consciousness only perceives change and this is documented in visual perception experiments (see e.g., Ref. [38]). Namely, if the retina remains fixed relative to the image there is no visual perception by the striate cortex neurons. The constant microsaccadic motion of the retina allows us to see images, and the image fades quickly if this motion does not occur[38, 39].

Within this model how does one get an experience of the room at all, if one does not have a prior experience of the room? However, the experience of the room itself is a change in the state of one’s own retina and post-retinal visual system and this is why the room can be perceived. In order for that to occur, the retina as a whole
needs to move through micro-saccadic motion; if the eye remains constant relative
to the image, there is no perception. First at the retina level the photons are
perceived through the operation of consciousness on the receptor cells. At a higher-
level in the hierarchy of the conscious flow, the person still needs to perceive (operate
or cause a conscious event in “his” sub-stream of consciousness by activating the
Corresponding neural correlate to the person’s consciousness) the image of the state
prepared by the post-retinal visual system. Therefore consciousness only perceives
changes by comparing the state of potential consciousness to the state obtained after
the operation of the attention of consciousness.

Another related question which can arise here is the following: It appears that
related brain activity generally precedes the occurrence of a perception which might
make it difficult to accept the idea that consciousness is primary. Does a related
brain activity precede the occurrence of the experience of an image? It is true that
some brain activity precedes the perception of the image, but is that activity the
perception of the image itself? Perception comes into being through the intervention
of consciousness, and without it there is no perception. One can be near an image but
he may not be seeing it. The retina may be “seeing” it but what we call the “person”
(a higher-level conscious operator) does not see it. We can imagine a person with
damaged striate cortex with perfect eyes; he will not see the image which his retina
“sees”. Therefore, the brain activity of the pre-cortex visual system still takes place
with no perception of the image by the person. This activity might be confused with
the perception itself of a more processed image. This argument can go deeper in the
brain until we encounter Von Neumann’s notion of the “abstract ego”. The brain
activity, which seems to precede the perception, occurs as any particular conscious
sub-stream, corresponding to the various brain parts, becomes “conscious” (by means
of a conscious event entering the Universal stream through this sub-stream) of some
precursor of the higher level perception, in the vast tree-like hierarchical structure
of flow of consciousness.

These are simple examples from our everyday experience which are only given
to demonstrate the process of how consciousness brings about events. As we have
already discussed, this does not imply that we should require the presence of a body
of a “sentient being” for something to come into existence, because an event can
arise in the Universal stream of consciousness. The observed universe is the body of
the Universal consciousness! Many objections to previous attempts to interpret
quantum theory using consciousness boil down to the requirement that consciousness
is owned by the bodies of sentient beings.

2.4 The Emergence of Matter

We have discussed the state of potential consciousness and the operation of con-
sciousness on that state which produces an event which is added to the stream of
consciousness. These operations can occur at any level in the stream of conscious-
ness, such as at an individual sub-stream of consciousness or at the Universal stream
of consciousness.
What is the ontological status of space-time and quantum fields? In this paper an attempt is made to construct an ontology based fundamentally on consciousness. Then, we take both the quantum fields and space-time structure, that gives the space-time relationships between them, to be basic elements in what we call the Universal Mind or Universal Consciousness. Therefore space-time and quantum fields are experiences or contents of the universal stream of consciousness to which our experiences all belong. As we will show in Sec. 4 the parameter of time used in physics is related to the order of occurrence of these conscious events which take place in the Universal stream of consciousness. In Sec. 5 we show that, the perception of space and motion are also based on conscious events which, along with their associated felt qualities, enter the Universal stream of consciousness.

The emergence of matter out of the operation of consciousness occurs at the Universal stream of consciousness, therefore, these events seem to us, to the individual stream of consciousness, far more stable, long lived, persistent, namely, they seem to exist “when no one is looking”. We generally postulate that when any new event occurs at any level in the Universal stream of consciousness, it changes the state of potential consciousness, and, therefore, it can have observable effects at, or effects that will influence, any sub-stream.

The potential consciousness and the actor or the operation of consciousness are primary. The stream of conscious events, which as they occur modify the state of potential consciousness for later events to be added to the stream of conscious events, are emergent. Consciousness as an actor or an operator is beyond time. The Big-Bang itself is an event in the Universal stream of consciousness. However, the Universal potential consciousness and the operational consciousness are always present and the Big-Bang, as well as all other events, are manifestations of the Universal potential consciousness.

2.5 The Emergence of the Brain

How does Mind (consciousness) use the already realized events in consciousness to allow the manifestation of more complex perception or concepts (which are also events)? First, these rather simple events discussed in the previous subsection enter the Universal stream, and then the emerging complexity is the manifestation of higher-level conscious events in the Universal stream of consciousness. Therefore simple events flow into more complex structures to represent these higher-level conscious qualities or concepts. We can also represent life by this flow, and, at some level of manifestation of the conscious potential, the cell emerges and then the brain/body emerges which are manifestations of higher-level conscious operations. The little streams flow into or merge into greater streams to create a larger flow or higher-level streams and these higher-level streams merge into higher-yet-level streams and so on. At some level the neurons or neural networks or other structures in the brain emerge as manifestations of concepts, feelings, memories and so on. Therefore, we conclude that any conscious quality, when it becomes manifest, has a counterpart in the brain and in an individual stream of consciousness (which is also part of the
Universal stream). The neurons or other central nervous system structures are the neural correlates or manifestations of the conscious concepts (or percepts)\[40].

How do neural correlates represent concepts? For the case of a brain, we postulate the restriction that the action of the conscious concept on the potential consciousness must be to restrict the potential consciousness to one in which the probability for a particular concept to hold is unity (certainty): the neural correlate of the conscious concept must be actualized. All brain activities incompatible with the conscious-concept and its neural-correlate must be projected out. In order for this to make sense a correlation must hold between the concept in consciousness and some component part of the state of potential consciousness (as it will become clear, this is the quantum state of the brain, defined by tracing over the other degrees of freedom except those of the brain). The pattern of brain activity, can be a pattern that has component parts scattered over the brain. As we discussed the allowed set of concepts in consciousness must include all those that anyone has ever had, and for any personal stream of consciousness, all the concepts that have appeared in that person’s stream of consciousness, in association with its neural correlate; the concept will always have its neural correlates distributed over the brain, and the concept will be able to actualize the corresponding neural correlates. That is, the binding problem is solved by postulating that the concept causes the collapse which actualizes the connection between the concept and the neural-correlates.

As we discussed we have postulated the existence of the state of the Universal potential consciousness. The particular brain contains the neural correlates of the concepts or qualities of the particular stream of consciousness. Because of the existence of the brain with its neural correlates it makes sense to consider the personal potential consciousness, which means a state where we pre-assign likelihoods only to concepts which already have a neural correlate in the particular brain. It is possible for a particular stream of consciousness to come “in contact” with the Universal consciousness. When this “contact” is established an insight comes forth on the particular stream of consciousness. For this to occur, the operator which carries out measurements in the brain has to be suspended. This operator is made out of the old contents and it is acting on the already existing neural correlates. The process of thought which is a process of measurement in the brain should momentarily halt in order for this contact with the Universal state of potential consciousness to become possible. The reason is that the action of measurement creates decoherence and collapses the state of local potential consciousness to a particular concept with an already existing neural correlate. Therefore, when these local measurements cease, the state of potential consciousness becomes coherently entangled with the Universal state of potential consciousness. When this Global state of potential consciousness is established and all the brain activities cease, it becomes possible to establish a correlation between a new concept from the Universal mind and a new neural correlate in the brain and, thus, a new event enters the personal stream of consciousness. We postulate that this is the process of a new perception, the process of creation, the process of evolution, the process of the growth of a child, and the process of acquiring an insight.
3 MATHEMATICAL DESCRIPTION

In Sec. 10 (appendix) we present as example where we use earlier contents of our stream of consciousness (the real numbers) to project a new concept (the solution to the equation \( x^2 + 1 = 0 \)) onto a basis formed by the old concepts (the real numbers). In the same sense, in an experimental situation to measure the position of a microscopic particle, we begin with the concept of position which is a macroscopic experience, and we build instruments appropriate to measure or to project this content of our streams of consciousness. This macroscopic experience of space is a content of our streams of consciousness created from direct macroscopic experiences, events which enter the stream of our consciousness by interacting with macroscopic objects. We cannot use a real conscious being to interact directly with the microscopic world and to make measurements in the way our brain does (it is actually our human consciousness which does it through the brain) by direct perception as described in Sec. 2.5. Instead, we construct instruments to measure quantities based on our known concepts and therefore they do not have the capability to measure an unknown concept to us. This is a process of projection and this process, as was demonstrated by the example, can be described by writing the potential outcome of the Newton-Raphson operation as a linear combination of pre-ascribed likelihoods for events, which correspond to known concepts, to occur.

The example in the appendix demonstrates that we can use linear spaces and operators to describe a situation in which we consider a new realm where perception of new concepts is required in order to be able to build a rational description of our experiences there. However, due to restrictions of our own stream of consciousness, such fundamentally new contents are not allowed to enter the stream. Therefore, in order to express the potential outcome of a conscious operation (or measurement), our consciousness uses as reference pointers the old contents of our consciousness which entered the stream of our consciousness as a result of earlier experiences (or earlier conscious events which correspond to definite neural correlates). The result of such a restricted operational observation is a random one from a pool of potential outcomes, which obey a well-defined distribution, if the question is repeated many times.

The process of the operation of consciousness can be formulated mathematically, in order to describe the perception of matter. As in the example of the appendix, we will make use of a Hilbert space and operators acting inside this space to describe functions of our consciousness and potential consciousness; the role played by the eigenstates and eigenvalues of such operators was also demonstrated with the example. A more general mathematical description is as follows:

- We begin from the experienced dualism between consciousness (subject) and object (any experience in consciousness). Note, however, that both subject and the object (as experienced quality of the actual event which enters the stream of consciousness) are aspects of consciousness. The state of potential consciousness will be represented by a vector in Hilbert space. Using the Dirac
notation, we can write this state vector as $|\psi\rangle$ which is a linear combination of the basis vectors $|i\rangle$, with $i = 1, 2, ..., N$, namely, as follows

$$|\psi\rangle = \sum_{i=1}^{N} \psi_i |i\rangle.$$ (1)

The vectors $|i\rangle$ give all possible states of consciousness (states describing potential events) for the particular observable (concept) in question. In the case of a particular conscious stream of a person, these concepts are also associated to specific neural correlates scattered over the brain. All the $N$ vectors together form a complete basis set of states, namely, they cover all potential outcomes. In general, however, depending on the phenomenon which we need to describe, $N$ can be finite or infinite. In addition, the discrete variable $i$, labeling the basis elements, can be a continuous variable; in this case the summation in Eq. (1) should be replaced by an integration. The above linear combination implies that the observable is not in any of the potential states. Unless an observation takes place, all we can say is that there is a state of potentialities. This is so, not because we don’t know what the actual value of the observable is, it is so because there is no value in consciousness. What is the taste of a cake before tasting it? Obviously, this question is meaningless, the right question is: what is the potential taste of the cake before tasting it?

The state vector which is represented as a linear combination of potential experiences represents the state of potential consciousness not experiences in consciousness. It is through the operation of consciousness that one of the potential experiences can be materialized. Because of the potential nature of the state (i.e., that, which the state describes, is not actual yet before the experience) it is written as a mixture of possibilities. Each possibility is fundamentally distinct from any other. The result of the experience while unique, prior to the experience itself (when it is in potential), should be written in such a way that it is a mixture or a sum of probability amplitudes for each one to occur as opposed to just probabilities. The reason is that we need to end up with probabilities after the experience not prior to the experience. This is so in order to allow for the operation of consciousness to take place and then carry out the measurement of the experience by comparing the previous state of potential consciousness with the one after the operation in order to have an event. After this action we end up with real events with a probability given by the square of the coefficient in the linear combination multiplying the particular state that becomes manifest.

- Because consciousness needs to carry out measurements (operations) inside this space, to make an event happen, this vector space should have the property of finite measure and, as a result of these requirements, it is a Hilbert space. In such a space, a measure of the “overlap” between two states $|\psi\rangle$ and $|\phi\rangle$ is measured by the scalar product between the two vectors representing the two
states, namely,
\[ I = \langle \psi | \phi \rangle = \sum_i \psi_i^* \phi_i. \] (2)

The overlap of any state to itself, which is the square of the length of the vector, is normalized to unity, i.e., \( \langle \psi | \psi \rangle = 1 \) and this is possible when working in a Hilbert space. Depending on the nature of the observed phenomenon, \( \psi_i \) can be real or complex numbers, or other mathematical objects such as multi-component vectors. Then, consciousness operates, by means of a linear operator acting on this state vector representing potential consciousness. An event in consciousness is a change and this change, in general, is an operation acting on a previous state. How does consciousness measures this potential change? If attention is absent there will be no conscious event. For such an event to occur in consciousness, consciousness has to compare this state to its own previous state for the event to occur.

The state \( | \psi \rangle \) represents the state of potential consciousness, which is not realized yet. It can potentially lead to a real event or experience through the application of consciousness or attention of consciousness. The so-called real or physical event is a conscious quality (or quale) in the Universal stream, which consciousness projects “out there”. There is no difference or separation between the qualia and the real, the physical. This notion was discussed in Sec. 2.3. The physical is an experience in the Universal stream of consciousness. In the particular or individual stream another corresponding event enters, the one actualized in its central nervous system, when the observation by that person occurs. Therefore, the state is defined over potentially physical events, or potentially conscious events.

The “physical” or the mental event, or simply event, can be mathematically broken down into a two step process, (a) the action or an operation which applies a concept on the state of potential consciousness and transform the state of potential consciousness (by activating the corresponding object (or “material”) correlate) to a state representing the concept alone, \( | \phi \rangle = \hat{O} | \psi \rangle \) ( \( \hat{O} \) is the operator representing a particular action of consciousness) (b) the overlap of the changed state (after the operation) to the state of potential consciousness prior to the operation, i.e., \( M = \langle \psi | \phi \rangle \), corresponds to the conscious value or the quality of the applied concept. After this process, the potential becomes real, namely, it appears in consciousness, or equivalently, it is a physical event and it activates the objective-correlate.

In the example given in the appendix, how does consciousness find the solution to an equation? Using the language of the operational consciousness this can be formulated as follows. The Newton-Raphson operator \( \hat{O} \) creates the potential solution of the equation. When the state \( | x_{n+1} \rangle = \hat{O} | x_n \rangle \) and the previous state \( | x_n \rangle \) have large overlap we take it that the solution is found (or “observed”). This is how we decide that we have found the solution, namely when \( \langle x_n | \hat{O} | x_n \rangle = 1 \), within a resolution defined by our computer precision. In order to make sure that we found a solution independent of the initial condition, we may start from a state \( | \psi_0 \rangle = \sum_{l=1}^{M} | x_0 \rangle \)
and after application of the operator $\hat{O}$ several times, we stop when the overlap $\langle \psi_n | \hat{O} | \psi_n \rangle$ is maximum (or unity, if we keep normalizing the states $|\psi_n\rangle$).

- Therefore, every creative action of consciousness can be mathematically represented by an operator $\hat{O}$ applying an idea or a concept to the state of potential consciousness $|\psi\rangle$. This causes a change of the state of potential consciousness.

- This changed state of potential consciousness $|\phi\rangle = \hat{O}|\psi\rangle$, due to the creative operation of consciousness, remains in a state of potentiality until it is perceived or measured by consciousness’ appropriate instrument, again through the operation of consciousness. When this happens the event arises in consciousness from the state of potential consciousness.

- This new action of consciousness which causes the observation-perception-measurement is completed by the comparison of the two states, namely the one before the operation of consciousness, i.e., $|\psi\rangle$, with the one after the operation of consciousness, i.e., $\hat{O}|\psi\rangle$, which is taken to be the scalar product between the two states:

$$M = \langle \psi | \hat{O} | \psi \rangle.$$  \hspace{1cm} (3)

The result of this comparison is also the observed result of the measurement as was discussed in Secs. 2.3 and 3. When this operator is used to represent a real (non-complex) physical observable, i.e., $M = M^*$, the operator $\hat{O}$ is a Hermitian operator. More information on the properties of a Hilbert space and of Hermitian operators acting in such a space can be found in Ref. [17].

- Each particular operation of consciousness, represented by an operator $\hat{O}$ that represents a particular observable or observing operation, is characterized by eigenvectors and eigenvalues in the Hilbert space, namely,

$$\hat{O}|\lambda\rangle = \lambda|\lambda\rangle.$$  \hspace{1cm} (4)

The significance of the eigenvectors of $\hat{O}$ is that these are the only states of potential-consciousness that do not change by the particular act of consciousness, namely, through the application of the inquiry $\hat{O}$. The result of the measurement (or the conscious quality) is the corresponding eigenvalue because the projection of the result of the action, i.e., $\hat{O}|\lambda\rangle$ on the state $|\lambda\rangle$ itself, is the eigenvalue $\lambda$. The eigenstates are the only states which represent a lasting experience in consciousness through the perception which corresponds to the eigenvalue. This point is discussed by means of an example in the Sec. 10.

Next we schematically discuss the main points.

Let us consider two such operators, the operator $\hat{O}$ and its eigenstates/eigenvalues as defined above, and the operator $\hat{Q}$ with the following spectrum of eigenstates/eigenvalues:

$$\hat{Q}|\mu\rangle = \mu|\mu\rangle.$$  \hspace{1cm} (5)
Since the eigenstates of each of these operators form what we call a complete basis set of a Hilbert space, let us express any of the eigenstates of the operator $\hat{O}$ in terms of eigenstates of the operator $\hat{Q}$, namely:

$$|\lambda\rangle = \sum_{\mu} \psi_{\lambda}(\mu) |\mu\rangle, \quad \psi_{\lambda}(\mu) = \langle \mu | \lambda \rangle. \quad (6)$$

The meaning of this expression is as follows. First let us suppose that the measurement of the observable (or question) represented by the operator $\hat{O}$ transforms the state of potential-consciousness to a particular eigenstate $|\lambda\rangle$. The result of the measurement is the corresponding eigenvalue $\lambda$. The next observation or question to ask is represented by $\hat{Q}$, which may or may not be compatible with the previous observation $\hat{O}$. The result of a single observation corresponding to $\hat{Q}$ will transform the state of potential consciousness to an eigenstate $|\mu\rangle$ of $\hat{Q}$ corresponding to a definite conscious quality characterized by the eigenvalue $\mu$. The result of a single observation/measurement will bring about in consciousness only a single definite answer. This answer must correspond to an eigenstate of the operator $\hat{Q}$ because only the eigenstates of an operator are “robust” or “lasting” against the application of $\hat{Q}$. As we have already mentioned, this is the reason why we use eigenstates to represent any particular realizable state of potential consciousness. The particular state $|\mu\rangle$ which would be brought about in consciousness cannot be known (as discussed in Sec. 2.3), all that is known is that the previous state of potential consciousness is $|\lambda\rangle$. This particular state that arises in consciousness is a choice that consciousness makes.

In Sec. 10 we show that because of the limitation of consciousness’ observing instrument, the only way to possibly describe such an act of measurement is a distribution; namely, any one particular state is not a predictable outcome, whereas a particular distribution can be a predictable output of many measurements.

For the case of our example given above, this means that while the state of potential consciousness is $|\lambda\rangle$, i.e., an eigenstate of the observable represented by the operator $\hat{O}$, consciousness carries out a measurement of an observable represented by the operation $\hat{Q}$. A particular question can be the following $P_{\mu}$: “Is the state of potential-consciousness the one corresponding to the eigenvalue $\mu$?” This question is operationally applied using the projection operator defined as follows:

$$\hat{P}_{\mu}|\mu'\rangle = \delta_{\mu\mu'}|\mu'\rangle; \quad (8)$$

i.e., such that the outcome of its operation on the state $|\mu'\rangle$ and then projected back to itself (measured against itself) is given as

$$(\mu' | \hat{P}_{\mu} | \mu') = \delta_{\mu\mu'}.$$  

Namely, it is affirmative or negative depending on whether or not the state of potential consciousness agrees with that sought by means of the operational question $P_{\mu}$. 

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If the same question is applied on the state $|\lambda\rangle$ given by Eq. 7, we find

$$\langle \lambda | \hat{P}_\mu | \lambda \rangle = |\psi_\lambda(\mu)|^2,$$  

namely, the outcome of the projection would be the eigenstate $|\mu\rangle$ with eigenvalue $\mu$ and with probability $|\psi_\lambda(\mu)|^2$. Therefore, we can represent the projection operator in Hilbert space as $\hat{P}_\mu = |\mu\rangle\langle \mu |$.

4 COMPLEMENTARITY OF CHANGE AND TIME

Periodic change or fluctuation is a fundamental element of consciousness. Consciousness perceives time only through the direct perception of change through an event; the value of the time interval between two successive events in consciousness is only found by counting how many revolutions of a given periodic event took place during these two events. Therefore the notion of time is related to the sequential (ordered) events which allow counting, and the interval of time and change (in particular periodic change) are complementary elements and they are not independent of each other.

There is physiological evidence suggesting the direct perception of frequency. For example, we perceive the frequency of sound directly as notes or pitch, without having to perceive time and understand intellectually (after processing) that it is periodic. Another evidence of direct perception of frequency comes from the fact that color is perceived directly without the requirement that “one’s” consciousness is aware of any co-experience of time whatsoever. In addition, the retina receptor cells are highly sensitive and it has been shown that they can observe a single photon\[42, 41\]. Furthermore, in biological systems, receptors for what we refer to as time do not exist\[22\]. On the contrary, there is significant neuro-physiological evidence that the perception of time takes place via coherent neuronal oscillations\[43\] which bind successive events into perceptual units\[22\].

Nature responds to frequency very directly, and some examples are resonance, single photon absorption and in general absorption at definite frequency. The time-less photon, in addition to being a particle, can be thought of as the carrier of the operation of consciousness on the state of potential consciousness together with the correct instrument. When the operated state of potential consciousness is measured against its own state before the operation, a definite frequency is realized (or materialized). An instrument (such as the retina receptor cells) is needed to materialize the operation of consciousness, because matter is the necessary “mirror” to “reflect” (to actualize) the act of consciousness. At first glance it may appear that we have introduced a duality by separating consciousness and matter. Matter, however, as discussed in Sec. \[22\] is manifested consciousness at another level, at the Universal stream of conscious events.

Let us try to discuss evolution (or change) quantitatively. In order to describe any perception of change, our imagination invents a parameter which we call time which labels the various phases of change and we delude ourselves with the belief that such a parameter has independent existence from consciousness; time is only a vehicle or
a label used to facilitate the description of change. Therefore, we imagine the state of potential consciousness $|\psi(t)\rangle$, as a function of $t$, labeling the time of potential observation. We wish to discuss a periodic motion, so let us confine ourselves within a cycle of period $T$. For simplicity we will discretize time, namely, the states are labeled as $|\psi(t_i)\rangle$ where $t_1 = 0, t_2 = \delta t, t_3 = 2\delta t, ..., t_N = (N - 1)\delta t$, with $N\delta t = T$. These time labels have been defined and measured in terms of another much faster periodic change which we call it a clock. Let us assume that $\delta t$ corresponds to the “time” $T'$ of a single period of the fast periodic change of the clock, namely $t_i, i = 1, 2, ..., N$, are the moments when the “ticks” of the clock occur. Let us define the chronological operator $\hat{t}$ and its eigenstates

$$\hat{t}|\psi(t)\rangle = t|\psi(t)\rangle,$$

namely, we have assumed that the state of potential consciousness is characterized by a definite measured time. Notice, that we needed two periodic motions “running” in parallel in order to discuss the measurement of the period of the first in terms of the second (clock). Namely, we are unable within a single event in consciousness to know both the time and the frequency of the event. We have already discussed that physiological evidence given above, suggests that consciousness only experiences frequency not time as a fundamental conscious quality. Here we have put the cart before the horse by beginning from the imagined notion of time, which is only quantified through the periodic motion. We will next define the eigenstates characterized by definite period in terms of the states characterized by definite time.

Next, let us define the evolution operator or time-displacement operator, the operator that causes the change of the state of potential consciousness, namely

$$\hat{T}|\psi_i\rangle = |\psi_{i+1}\rangle, \quad i = 1, ..., N - 1,$$

$$\hat{T}|\psi_N\rangle = |\psi_1\rangle,$$

where $|\psi_i\rangle = |\psi(t_i)\rangle$, and the second equation above implies that because of the nature of the perception of the periodic change there will be no difference in the state after time $t = N\delta t$, i.e., the period $T$ of the periodic change.

In the case of periodic change, such as described by Eq. 12 all the eigenstates and eigenvalues of the operator $\hat{T}$, in terms of the eigenstates of the chronological operator, are given as follows:

$$\hat{T}|\omega_n\rangle = \tau_{\omega_n}|\omega_n\rangle, \quad \tau_{\omega_n} = e^{-i\omega_n\delta t},$$

$$|\omega_n\rangle = \frac{1}{\sqrt{N}} \sum_{i=1}^{N} e^{i\omega_n t_i} |\psi_i\rangle,$$

where $\omega_n = n(2\pi/T)$, and $n = 1, 2, ..., N$. Notice that the quantization of the levels of single periodic change is the same as that of the harmonic oscillator (here we have used natural units where the so-called “energy” is the same as the frequency and this is discussed later). This is so because we have not limited in any way the number of quanta (or atoms) which are observed.
The state which describes a periodic change is such that when the time-displacement operator acts on it, it behaves as its eigenstate. The significance of the eigenstates was discussed in Sec. 3. Namely, they are the only states of potential consciousness which do not change under the application of the inquiry, no matter how many times the inquiry (measurement) is applied. Therefore, the measurement in this case introduces no frequency uncertainty of the state of definite frequency. This state cannot be characterized by any definite value of time; for the change to be characterized by a definite frequency, an observation of regular periodic motion is required to continue forever.

Time \( t = m\delta t \) “elapses” when the time-translation operator \( \hat{T} \) acts \( m \) consecutive times on the state, namely, the time evolution of the state \( |\omega_n\rangle \) is

\[
|\omega_n\rangle_t = \hat{T}^m|\omega_n\rangle = e^{-i\omega_n m\delta t}|\omega_n\rangle = e^{-i\omega_n t}|\omega_n\rangle, \quad (15)
\]

\[
|\psi(t)\rangle = \sum_n c_n|\omega_n\rangle t = \sum_n c_n e^{-i\omega_n t}|\omega_n\rangle, \quad (16)
\]

Let us now consider the case where the change does not necessarily occur at a single period but it is a mixture of periodic changes of various characteristic frequencies. We begin from the frequency eigenstates Eq. 14 as the basis and let us define the time evolution of the state as

\[
|\psi(t)\rangle = e^{-i\hat{\omega}t}|\psi(0)\rangle, \quad (17)
\]

\[
\hat{\omega}|\omega_n\rangle = \omega_n|\omega_n\rangle, \quad (18)
\]

where the sum is over all the eigenstates of the time translation operation acting on the state of potential consciousness that characterizes the system. This latter equation can also be written as follows

\[
|\psi(t)\rangle = e^{-i\hat{\omega}t}|\psi(0)\rangle, \quad (19)
\]

\[
\hat{\omega}|\omega_n\rangle = \omega_n|\omega_n\rangle, \quad (20)
\]

where \( |\psi(0)\rangle \) is some reference state. Again the perception of frequency is direct and so in our description of nature we need to start by considering this perception as one fundamental building block of consciousness and not the perception of time.

Equivalently from Eq. 19 we can say that this is the solution to the following differential equation

\[
\hat{\omega}|\psi(t)\rangle = i\partial_t|\psi(t)\rangle, \quad (21)
\]

or equivalently

\[
\hat{\omega} = i\partial_t. \quad (22)
\]

We need to discuss why the above frequency operator characterizes the measurement of change. For simplicity let us go back to the discrete time domain. If consciousness applies the operator \( \hat{\omega} \) on the state of potential consciousness we have

\[
\hat{\omega}|\psi(t_i)\rangle = \frac{i}{\delta t}(|\psi(t_{i+1})\rangle - |\psi(t_i)\rangle), \quad (23)
\]
which is (apart from the multiplicative factor $i/\delta t$) the change of the state of potential consciousness. This change is evaluated by simply using as measure the instantaneous state of potential consciousness itself, i.e., by projecting the change onto $|\psi(t_i)\rangle$. This means that the expectation value $\langle \psi(t)|\hat{\omega}|\psi(t)\rangle$ is a measurement of the rate of change of potential consciousness.

Using Eq. 22 for the frequency operator, the following commutation relation between frequency and the chronological operator follows in a straightforward manner:

$$[\hat{t}, \hat{\omega}] = i.$$

(24)

In addition, the well-known uncertainty relation follows, namely,

$$\Delta \omega \Delta t \geq 1.$$

(25)

The uncertainty relationship between frequency and time can be easily understood as follows. Let us suppose that a changing state of consciousness is observed for a finite interval of time $\Delta t$. This observation time interval is also the uncertainty in time, because there is no particular instant of time inside this interval to choose as the instant at which the observed event happened. Even if the event seems to be regular or periodic inside this interval of time, there is an uncertainty as to what happens outside this interval. In fact, as discussed, nothing happens outside this interval because there is no observation in consciousness and thus no event there, only a potentiality. If we calculate the Fourier spectrum of such a changing event, no matter how regularly it evolves inside this interval, (with nothing happening outside of this interval) we will find significant amplitudes for frequencies in an interval range greater than $1/\Delta t$.

5 COMPLEMENTARITY OF MOTION AND SPACE

The next question which naturally arises is how consciousness perceives motion. Motion is associated with change of relative position. Let us inquire how consciousness perceives motion of a point-like object. In translationally invariant space, how does one know that motion occurs? There is no movement unless there is an observer and a change of the position of the object relative to that of the observer. Just as we did in the previous section, where we considered frequency (periodic change) and time as complementary observables, here, we will consider regular motion in space and spatial position as complementary observables in consciousness; namely, one needs the other in order to be perceived in consciousness. There is a tendency to think that space is out there “standing” even if the perception of motion was not there. However, the very definition of space requires the pre-conception of motion and the perception of space implies motion as a potential event. In the following section, we will discuss that motion is also a particular form of change and therefore we will require a relationship between frequency and wave-vector. For the case of motion, however, there is the field of space which can be used by consciousness to express this particular form of change, namely, motion; hence, momentarily time can be set aside. This point will become clear below.
Let us examine whether or not we can use the state of potential-consciousness representing position in space to understand the state of potential-consciousness representing motion. If a particle is observed to be in a particular fixed position in space, for example \( r \), we will represent the state of potential-consciousness by a state vector \( |r\rangle \). In order for this state to successfully represent the state of definite position, the operation of observing the eigenstate of the position should leave this state unchanged.

For the case of motion let us begin from these eigenstates of position and work in a bounded world with periodic boundary conditions. We then define the displacement operator \( \hat{T}_{\delta r} \), that causes the motion in consciousness, as follows:

\[
\hat{T}_{\delta r}|r\rangle = |r + \delta r\rangle, \tag{26}
\]

and if the position vector lies outside of the boundary of space it is mapped inside using the Born-Von Karman boundary conditions. In order to simplify the discussion, let us consider a one dimensional problem with periodic boundary conditions, namely a problem on a circle of length \( L \) with discrete positions \( x_i = (i - 1)\delta x \) labeled as \( i = 1, 2, ..., N \), and \( N\delta x = L \). Then the space-displacement operator is

\[
\hat{T}_s|x_i\rangle = |x_{i+1}\rangle, \quad i = 1, ..., (N - 1), \tag{27}
\]

\[
\hat{T}_s|x_N\rangle = |x_1\rangle. \tag{28}
\]

In order for consciousness to perceive motion, we need to define a state of potential-consciousness which, when the displacement operator acts on it, does not change it. Mathematically, assuming that the eigenstates of the position operator form all possible outcomes of a measurement of position, it is possible to write down all the eigenstates and eigenvalues of the operator \( \hat{T}_s \) in terms of the eigenstates of the position operation. They are given as follows:

\[
\hat{T}_s|k\rangle = \lambda_k|k\rangle, \quad \lambda_k = e^{-ik\delta x}, \tag{29}
\]

\[
|k\rangle = \frac{1}{\sqrt{N}} \sum_{i=0}^{(N-1)} e^{ikx_i}|x_i\rangle, \tag{30}
\]

where \( k = (2\pi/L)j \), with \( j = 0, 1, 2, ..., (N - 1) \) and the states \( |x_i\rangle \) are the position eigenstates along the circle. The state which describes a periodic motion is such that when the time displacement operator (representing consciousness) acts on it, it does not change no matter how many times consciousness applies the inquiry. Therefore, the measurement in this case introduces no wave-number (k) uncertainty of the state of definite k. This state cannot be characterized by any definite value of position.

Since the basis \( k \) forms a complete set, we can express the position basis as a linear combination, namely

\[
|x_i\rangle = \frac{1}{\sqrt{N}} \sum_{j=0}^{(N-1)} e^{-ik_jx_i}|k_j\rangle, \quad k_j = \frac{2\pi}{L} j. \tag{31}
\]
These equations can be generalized from a discrete one-dimensional index to a contin-
uous three-dimensional one, in the usual way. Namely,

\[ \hat{T}_{\delta r}|k\rangle = \lambda_k |k\rangle, \quad \lambda_k = e^{-i\delta r}, \quad (32) \]

\[ |k\rangle = \frac{1}{\sqrt{V}} \int d^3 r e^{ik\cdot r}|r\rangle, \quad (33) \]

where \( k = (k_x, k_y, k_z) \), and for periodic boundary conditions each of the components
is given by \( k_w = 2\pi/L_w n_w \) (\( w = x, y, z \)), with \( n_w \) taking integer values and \( L_w \) are
the dimensions of the box of volume \( V \) bounding the space.

The position eigenstate \(|r'\rangle\) can be reached from \(|r\rangle\) by acting with the space-
displacement operator as follows

\[ |r'\rangle = e^{i\hat{k}\cdot(r'-r)}|r\rangle, \quad (34) \]

\[ \hat{k}|k\rangle = k|k\rangle. \quad (35) \]

It is straightforward to see from the last equation, that the operator \( \hat{k} = (\hat{k}_1, \hat{k}_2, \hat{k}_3) \)
is given by

\[ \hat{k}_i = -i\partial_{x_i}, \quad (36) \]

where \( x_i, i = 1, 2, 3 \) are the three components of \( r \). As was discussed in the case of
the frequency operator, in a similar way it can be shown that the above wave-vector
operator characterizes the measurement of change through motion. Namely, when
consciousness applies the operator \( \hat{k} \) on the state of potential consciousness apart
from the multiplicative factor, the change of the state of potential consciousness
is obtained. This change is evaluated by projecting the change onto the state itself.
This means that the expectation value \( \langle \psi | \hat{k} | \psi \rangle \) is a measurement of the “rate” of
change of potential consciousness with respect to spatial variation.

Using Eq. 36 for the wave-vector operators, it can be shown in a straightforward
manner, that the following commutation relation between position and momentum
operators,

\[ [\hat{x}_i, \hat{k}_j] = i\delta_{i,j}, \quad (37) \]

as well as the following uncertainty relations,

\[ \Delta x_i \Delta k_i \geq 1, \quad (38) \]

are valid. This uncertainty relationship can be easily understood by means of a similar argument as one provided for the case of the frequency-time uncertainty
(Eq. 25).

There is direct experimental evidence that consciousness perceives directly states
of well-defined wave-vector\[38, 39, 44\]. There is a large number of striate cortex neurons
which only respond to motion in a well-specified direction\[38, 39\]. In particular
in Ref.\[44\] the analog of the two slit interference experiment is introduced for the
visual perception of the mammalian brain. The response of the cat striate cortex neuron to a single line of light flashed alternatively at two parallel locations separated by distance \( d \) was recorded. The response of the direction-sensitive neuron of the striate cortex (area 17) was found to fit the form

\[ f(d) = \sin(kd + \delta)e^{-d/\xi}, \]

as a function of the distance \( d \) and \( k = 2\pi/\lambda \), with \( \lambda \) the distance where the optimum response is found. Therefore the mammalian brain’s study indicates that consciousness is wavelength selective. Indirectly this fact was already known to us, because we can see definite colors.

Our operations, applied on observation instruments of the outside world, must be the same operations which we apply inwardly, otherwise what makes us apply different operations for observing two parts of the same world? Because the boundary between inward and outward, between the observed and the observing instrument can be arbitrarily shifted\textsuperscript{[17, 18]}

Therefore, consciousness naturally understands motion as well as position as fundamental elements of consciousness. However, as it was discussed, they are also complementary observables, each having no independent existence from the other. The Newtonian conception of classical mechanics (the notion of the independent existence (absolute) of the framework of space and time and, as a result, the notions of rates of change) through the successful application of its laws to describing all macroscopic motion, has given a tremendous credit to these notions as existing independently. However, as we have recognized now, this conception is not accurate.

6 EQUATIONS OF MOTION

6.1 Non-Relativistic Quantum Mechanics

Let us summarize what has been shown so far. First, the expressions for the wave-vector (Eq. 36) and frequency (Eq. 22) operators are generally derived. Using these relations, the commutation relations between position and momentum operators given by Eq. 37 as well as the uncertainty relations Eq. 25 and Eq. 38 follow in a straightforward manner.

In the case where the uniformity of space is broken, namely the various positions of space are biased differently (for example by an external field), the situation is somewhat different. Let us consider the discretized one-dimensional space (with periodic boundary conditions) in order to demonstrate what happens in this case. The basis state vectors are \(|x_i\rangle\), labeled by the discrete positions \( x_i = (i-1)\delta x \) where \( i = 1, 2, ..., N \) and \( N\delta x = L \). When the frequency operator is applied on any such position eigenstate \(|x_i\rangle\) we can write the following general expression

\[ \hat{\omega}|x_i\rangle = \epsilon(x_i)|x_i\rangle - (t_1|x_{i+1}\rangle + t_i^*|x_{i-1}\rangle) - (t_2|x_{i+2}\rangle + t_2^*|x_{i-2}\rangle) - .... \]  

(40)

Notice that the coefficients of \(|x_i + n\rangle\) and \(|x_i - n\rangle\) must be complex conjugates because the operator \( \hat{\omega} \) is Hermitean as discussed. Note that in general the coefficients \( t_i \) could also depend on \( x_i \) but we consider the simplest case. Let us initially
consider only “nearest-neighbors hopping”, i.e., we neglect all the terms $t_n$ with $n > 1$. Furthermore we can choose an overall phase factor such that $t_1$ is real. It is straightforward to show that in the continuum limit $(\delta x \to 0)$ we obtain

$$\hat{\omega}|x\rangle = \left( u(x) - \frac{1}{2\mu} \frac{d^2}{dx^2} \right)|x\rangle,$$

where $u(x) = \epsilon(x) - 2$ and $1/2\mu = t(\delta x)^2$. Note that if we consider the terms proportional to $t_n$ with $n > 1$, they also give rise to the same second derivative term with a redefined value of $\mu$.

The term $u(x)$ describes a possible spatial relative bias which in general can be made time-dependent. To quantify the description of motion, we define a function of space-time $u(r,t)$ which we call potential frequency and we write the total frequency operator as two contributions. In momentum space basis and in three-dimensions, the frequency operator can be written as

$$\hat{\omega}(\hat{k}) = \frac{1}{2\mu} \hat{k}^2 + u(r,t).$$

Here we would like to identify the frequency and wave-vector with the energy and momentum of a particular mode; they are different words for the same observable in macroscopic mechanics. To make contact with experimental results we need to use the same notions and units for these quantities. This implies that when we use units such that $\hat{H} = \hbar \hat{\omega}$, and $\hat{p} = \hbar \hat{k}$, the energy and the momentum operators are the same as the frequency and wave-vector operators. Note the absence of Planck’s constant from these relations and from Eqs. (22,25,36,38). Planck’s constant enters in Quantum Mechanics because of the traditional or historical way of evolution of the description of nature starting from Newtonian notion of mass which in our notation is $m = \hbar \mu$.

With these identifications, Eq. (21) is the Schrödinger equation with

$$\hat{H} = \hbar \hat{\omega} = \frac{\hat{p}^2}{2m} + \hat{V}(r,t),$$

$$\hat{p} = \hbar \hat{k}, \quad \hat{V}(r,t) = \hbar \hat{u}(r,t), \quad m = \hbar \mu.$$  \hspace{1cm} (43)

Schrödinger’s takes the form of Newton’s equation in the limit where, in any given eigenstate, the contribution of the first term in Eq.(43) is much smaller than the contribution of the second term. In addition, classical mechanics describes the behavior of an ensemble of a huge number $N$ of such indivisible microscopic systems together. Therefore, the notion of the energy used in classical mechanics is $\sum_{i=1}^{N} \hbar \hat{\omega}_i$ and the momentum of the system will be $\sum_{i=1}^{N} \hat{p}_i$.

### 6.2 Relativistic Quantum Mechanics

The validity of relativistic mechanics is additional support for the starting point of the present paper that everything that happens, takes place in consciousness.

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Namely, space and time are not independently existing notions but they are related through the fact that periodic variation (frequency) and spatial variation (wave-vector) are both changes related to events in consciousness. In units where we measure distance by the time it takes light to "travel" it, frequency and wave-number for light are related through the relation \( \omega = ck \). This oneness of space and time is ultimately linked to the oneness of change (namely motion is change) as the only generalized event that can possibly occur in consciousness.

In the case of relativistic mechanics, where we need to impose invariance under Lorentz transformations, using the four-vector notation \( ck^\mu = (\omega, c \mathbf{k}) \), where \( c \) is the speed of light, we have

\[
k^\mu k_\mu = \omega^2 - c^2k^2 = \left( \frac{mc^2}{\hbar} \right)^2,
\]

and by substituting the operators given by Eq. 36 and Eq. 22 for \( k_i \) and \( \omega \), respectively, the Klein-Gordon equation is obtained

\[
\left[ -\nabla^2 + \frac{1}{c^2} \frac{\partial^2}{\partial t^2} + \frac{c^2m^2}{\hbar^2} \right] |\psi\rangle = 0.
\]

In the case of the dispersion relation \( \omega^2(k) = c^2k^2 \) the wave equation for a massless particle is obtained.

Similarly, while on the one hand we impose invariance under Lorentz transformations, we may assume that the existence of a vector, such as the spin, breaks the rotational symmetry of space. Following Dirac, the following frequency operator is obtained by taking the square root of the operator in Eq. 46

\[
\hat{\omega}(\mathbf{k}) = c\vec{\alpha} \cdot \mathbf{k} + mc^2\hat{\beta},
\]

where \( \vec{\alpha} = (\hat{\alpha}_1, \hat{\alpha}_2, \hat{\alpha}_3) \) and \( \hat{\beta} \) are four Hermitian operators acting on the spin variables alone. The squares of these operators are unity and their components anticommute, in order for the equation \( \hat{\omega}^2 |\psi\rangle = -\partial_t^2 |\psi\rangle \) to be the same as the Klein-Gordon equation. Namely,

\[
(\hat{\alpha}_i)^2 = 1, \quad \hat{\alpha}_i \hat{\alpha}_j + \hat{\alpha}_j \hat{\alpha}_i = 0 \quad (i \neq j),
\]

\[
\hat{\beta}^2 = 1, \quad \hat{\alpha}_i \hat{\beta} + \hat{\beta} \hat{\alpha}_i = 0.
\]

By substituting the frequency (Eq. 22) and wave-number (Eq. 36) operators in Eq. 47, the Dirac equation is obtained.

7 MEASUREMENT AND STATE VECTOR COLLAPSE

Theory does not describe what actually happens independently of the operation of consciousness, it describes what is observable in consciousness. It elegantly describes our experiences as “events” in consciousness caused by consciousness’ operation. This implies that the theory should describe at once the process of observation
together with the description of the event, as opposed to describing separately what happens and then leaving the description of the process of observation for a later stage. Namely, as it has been repeatedly discussed, we cannot possibly describe what happens outside consciousness, without introducing the presence of the operational observer in the very description of what happens. What instead theory describes is the very process of operational observation. This implies that in order to understand the process of measurement we do not need an additional theory of measurement, the theory itself is the theory of observation.

Theory should describe what we operationally do to observe. It describes how consciousness operates upon itself in an event of observation and what the potentialities of observation are depending on what this operational process does. Therefore, there is no difference between the theory of what “happens” in nature and the theory of measurement. Quantum theory is the description of what happens in consciousness, namely what happens during the process of observation and how we should describe the evolution of the state of potential consciousness between observations.

While there is only one consciousness, particular observing instruments related to consciousness observation sites can reflect particular events. A particular instrument or observation site of consciousness is realized when the totality is divided into an observing instrument and the rest which plays the role of the observed. A particular measurement consists of a “question” that consciousness has decided to “ask” by a) sectioning the whole into an observed and an observing instrument. The way this division is chosen by consciousness reflects the nature of the question to be asked. The experimental instrument is used only to materialize, or to operationally apply, or to reflect the question. This instrument is made to mimic the operation of consciousness known from experience (see discussion of Sec. 2.5 and Sec. 3). b) The question is operated by allowing the reunion (interaction) between the observing instrument and the observed and this reunion forces a changed state of potential consciousness c) this changed state is measured relative to the state of potential consciousness prior to the application of the question. This process causes an experience or event in consciousness and in the case of quantum theory it corresponds to the state collapse.

Let us divide the universe, the closed system, into an observed subsystem $S$ and an observing instrument $O$. Let the eigenstates of $S$ be denoted by $|\alpha\rangle$ and the eigenstates of the observing instrument be $|a\rangle$. These eigenstates among other quantum numbers are characterized by a quantum number $a$ which are the eigenvalues of an observable $\hat{a}$ which is a property of $O$. For the system $O$ to play the role of a measuring device of the property $\hat{a}$ of $S$ the following are required:

1) The eigenvalues of $\hat{a}$ must be in one to one correspondence with the eigenvalues $\alpha$ of an observable $\hat{\alpha}$ of $S$. This correspondence is declared by the function $a = f(\alpha)$ and it can be used as the measuring scale. Namely, by observing the value of $a$ on the measuring scale of the instrument $O$, we actually observe the corresponding value $\alpha$ characterizing $S$. 

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2) While in general the state of the combined system after their interaction is

$$|\Psi\rangle = \sum_{\alpha, a} \Psi_{\alpha, a} |\alpha\rangle|a\rangle,$$

(50)

for O to play the role of an observing instrument, the choice of the system O, (namely, the particular separation of the whole into an observing instrument and the observed) should be restricted in such a way that the state of the whole system after their mutual interaction is the following linear combination \[17, 18\]

$$|\Psi\rangle = \sum_{\alpha} \Psi_{\alpha} |\alpha\rangle|f(\alpha)\rangle.$$

(51)

Namely, in the linear combination, a pair of states $|\alpha\rangle|a\rangle$ has a non-zero contribution only if $a$ and $\alpha$ are eigenvalues of the instrument’s observable $\hat{a}$ and of S’s observable $\hat{\alpha}$, such that $a = f(\alpha)$. If we have made a table of these corresponding states by “looking” at the state of the system O, we know in which state the system S is after the measurement.

In our case, the whole system includes the body of the observer. In particular, the measuring instrument could be any part of the body of the observer. However, even in this correlated state of instrument and object, there is no possibility of a collapse. What would cause the combined system to choose a particular state, i.e., a particular combined state $|\alpha\rangle|a = f(\alpha)\rangle$? What would make the whole system decohere? There is nothing outside of it to help it decohere itself.

Consciousness is the only agency which can make that choice. This, from moment to moment, different experience of the universe, is what causes the collapse and this point has been appreciated some time ago (see, e.g., \[18\]). To understand the wave function collapse in terms of very simple examples of consciousness’ operation at the so-called personal subjective world, the reader is referred to Secs. 2.3, 2.4 and 2.5. There, it was discussed that the state of potentiality, when observed, becomes a definite state representing a definite conscious quality and therefore it acquires a definite value.

Hence, within this theory, there is no puzzle in the so-called Schrödinger’s cat paradox \[3\] because of the Universality or non-locality of consciousness; as discussed, there is no separation between what happens and what is measured; namely, there is no issue with the state vector collapse and if an event happens, through the projective action of consciousness, it has occurred in one and the same consciousness.

The following discussion is related to the Einstein, Podolsky and Rosen (EPR) paradox \[2\] and the results of the experiments by Aspect et al. \[46\] as well as the attempts recently made for various forms of teleportation \[47\]. Starting from the character of consciousness we have shown that space and time are observables and they do not exist “out there” independently of events in consciousness (Universal and particular). While events happen in consciousness, the events themselves can be characterized by space-time labels only when these events and the measurement of space time coordinates can be simultaneously observed (and their observation is not incompatible with the observation of their complementary observables) by
the observing instrument. Therefore, because of the non-locality of consciousness, an observation which is caused by some action at a particular position in space, influences the entire universe. In the particular example of Bohm’s formulation of the EPR paradox when the observation occurs anywhere, the pair of spins together as a single event is born in consciousness from the state of potential consciousness, namely from the spin-singlet state describing a pair of correlated spins. In other words, in this case it is not possible to observe just one spin; the very observation of that one spin is, at the same time, observation of the other spin. Therefore, because of the non-locality of consciousness there is no paradox.

Causality, on the other hand, applies to two different or separate events in consciousness which are both characterized by definite space and time labels as observed. For example, if an event occurs, where a measurement is made of the position of the particle at a measured instant of time $t_1$ and then in a separate event its position is measured at a different measured instant of time $t_2$, the second event should lie in the light cone which has the first event as its origin. In addition, the evolution of the states of potential consciousness between such operations of consciousness is deterministic, bound by law and governed by cause and effect.

In any attempt to understand the process of any felt experience, namely how it occurs using a mechanistic theory, even using quantum mechanics, the subject or consciousness itself will never be “seen”. Therefore, the result of a particular operation of consciousness cannot be predicted, only the statistical result of many such measurements is predictable. Quantum theory allows for this intervention of consciousness, namely via the projection process where the result of this projection is observed as a destructive interference. A good example is equilibrium quantum statistical mechanics, where in the canonical ensemble for example, one assumes that there is such a phase decoherence which allows one to consider the trace of $\rho \hat{O}$ ($\rho$ is the density matrix and $\hat{O}$ an operator representing an observable) as an observable only. This is so because of phase decoherence introduced by the multiple interaction of the bath, with which the system is in equilibrium. This interaction is actually nothing but an external (to the subsystem) “measuring” instrument through which the subsystem is continuously observed or projected. Through such an overwhelmingly large number of observations of an observed subsystem which are all averaged out, we are allowed to introduce the notion of temperature and entropy of the subsystem.

In addition, non causal evolution can exist because of consciousness’ choice of the dividing line, which bisects the whole into an observed and observing instrument. Therefore, consciousness is the ultimate judge that simply makes the choices about what questions to ask. Through such choices the universe evolves in a direction prepared by the sequence of all these events in consciousness. This process requires the division of the observed universe into an observed part and into an observing instrument. Consciousness participates in this division silently through the choices and the process of various projections made coherently on the various material parts of the instrument, so that the action as a whole leads to a coherent measuring instrument made for the particular reason of measurement (or reflection) and requires
no external energy and no external material action. Notice that this choice, which is the moment of the wave-function collapse, costs no external energy at all.

8 SUMMARY

A theory of consciousness was presented from which quantum theory follows as the quantitative description of the operation of consciousness on a state of potential consciousness. The so-called material aspects of nature are experienced due to events in our particular sub-streams of a Universal stream of conscious flow. These events give rise to conscious qualities, such as concepts, sensations, feelings, through which we experience the world. In addition, through the conscious process of objectivation which is part of the general perception process, they are projected into “actual” events. The persistence of the material Universe “when no one is looking” is due to our postulate that our streams of consciousness are sub-streams of a Universal conscious flow. When an event occurs, it happens in the Universal consciousness directly or through the particular sub-streams. Notice that we can describe everything using exclusively aspects of a Universal consciousness.

The so-called seat of consciousness is not to be found anywhere in particular because the objects are products of consciousness; instead what can be perceived directly is not consciousness, but rather the process of the operation of consciousness and the events which occur in consciousness. In order to discuss the operation of consciousness, we introduce the state of potential or unmanifested consciousness as a state representing the contents (or constructs, or abstractions, or ideals, which manifest themselves as conscious qualities or qualia, when they become experiences) of all previous experiences each assigned a weight to be related to its probability of its projection when a future experience takes place. Consciousness operates on this state of potentiality and there are two different operations; the creative operation of consciousness and the operation of conscious inquiry. In addition, the potential consciousness is also a tool to describe intuition or creative advance, a state of “pregnancy” of consciousness and a tool to describe the process of evolution.

The creative action of consciousness can be thought of as an operation of an idea or a concept (which strictly speaking has no exact material representation) on the state of potential consciousness. This causes a change of the state of potential consciousness. Consciousness either perceives a change in its own state, which is recognized by the process of measurement or projection or thought, or asks a question (inquiry) by acting on the potential state. The result of such an operation is to manifest the conscious concept either (a) on the measuring instrument or (b) in the case of the brain, the action of the conscious-concept is to actualize the neural correlate in the brain, which is identified with the so-called collapse of the quantum state. When an event happens, it always happens due to the action of the conscious concept from the Universal stream or sub-streams of consciousness on the state of potential consciousness.

A simple framework to quantify the description and to apply it to the science of perception and more generally to the science of consciousness as well as physics,
is to work with operators acting in linear spaces representing potential states of consciousness which are based on a few basic concepts. An operator represents the direct operation of the conscious-concept and, in general consciousness, on the state of potential consciousness. The outcome of measurement or experience is (i) to collapse the state describing the potential for consciousness to a particular state representing a corresponding conscious concept and (ii) the value of the observable is represented as the result of evaluating the overlap between the change of the state of potential consciousness after the action of consciousness and its own state of potentiality before the action of the operator; namely, consciousness uses the previous state of potential consciousness as the measure to evaluate the quality and degree of change.

We begin from elementary contents of the Universal and particular streams of consciousness: (a) the notion of frequency and periodic change and its complementary concept of time, (b) the notion of space and its complementary concept of motion in space. We use neuro-physiological evidence to argue that consciousness can directly observe frequency and wavelength, independently of the experience of time and space. We also find that the equation of motion of the state of potential consciousness, when it is restricted to the potential observation of the spatial position of a particle, is Schrödinger’s equation, where the state of potential consciousness is identified with the wave-function of the particle.

Furthermore, we show that this theory is free from the paradoxes and puzzles present in the usual interpretations of quantum theory, such as the EPR paradox and the Schrödinger cat paradox. In addition, the two well-known postulates of von Neumann’s quantum theory of measurement follow from these more general philosophical ideas. Therefore, the theory is also free from the well-known problem of wave-function collapse which appears in the quantum theory of measurement.

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10 APPENDIX

10.1 Mathematical Description of the Operation of Consciousness: An Example

A child’s conceptual development might proceed first by conceiving the integer numbers, then the fractions and then the irrational numbers. The concept of irrational
numbers is introduced operationally as a solution to algebraic equations, say, for example $\sqrt{2}$, as the solution to the equation $x^2 = 2$. However, an exact solution to this equation can never be a content of a particular brain (due to its limitation) but only fractional approximations to the solution or sequences with limit the solution. While with this concept of “getting arbitrarily close” satisfies us most of the time, there are phenomena, such as chaos, where even the slightest departure from exactness leads to qualitatively different states. Pythagoras demonstrated, however, that $\sqrt{2}$ can be grasped through a geometrical operation of consciousness if we abandon our attachment to one dimension (real axis) and go to two dimensions. The reason is that while consciousness is undivided, with no beginning and no end, a particular instrument of it (e.g. the brain), is always limited. Therefore, such an operational definition through an infinite series of approximants may not always be satisfactory.

To demonstrate our point, let us go ahead and use such an iterative process which provides closer and closer approximants to the solution of the equation $f(x) = 0$. In particular let us adopt the Newton-Raphson method as the operational definition of the solution of the equation $f(x) = 0$, where the following recursion relation

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

is iterated starting from $x_0$. Through this process the solution is conceptualized by the intersection of the curve $f(x)$ and the real axis.

Now, let us define the Newton-Raphson operator as follows:

$$\hat{O}|x_n\rangle = |x_{n+1}\rangle, \quad x_{n+1} = O(x_n) = x_n - \frac{f(x_n)}{f'(x_n)}. \tag{52}$$

In the case of the equation $f(x) = x^2 - 2 = 0$, the recursion relation is $x_{n+1} = (x_n^2 + 2)/2x_n$. If we iterate this equation for a large number of operations we find that the limiting distribution approximates a delta function at $x_0 = \sqrt{2}$. Using the language of the operational consciousness this can be formulated as follows. The operator $\hat{O}$ creates the potential solution of this equation defined above. When the state $|x_{n+1}\rangle = \hat{O}|x_n\rangle$ and the previous state $|x_n\rangle$ have large overlap we claim that the solution is observed. This is how we decide that we have found the solution, namely when $\langle x_n|\hat{O}|x_n\rangle = 1$, within a resolution defined by our computer precision. In order to make sure that we found a solution independent of the initial condition, we may start from a state $|\psi_0\rangle = \sum_{l=1}^M |x_l^0\rangle$ and after application of the operator $\hat{O}$ several times and we stop when the overlap $\langle \psi_n|\hat{O}|\psi_n\rangle$ is maximum (or unity, if we normalized the states $|\psi_n\rangle$).

This operational procedure is used here to simulate the operation of thought and of consciousness. Namely, the operational procedure which applies a question on the state of potential-consciousness and obtains an answer by comparing the states before and after the application. In addition, it can be also used to represent the experimental measurement procedure.

Next, let us assume that we wish to find the solution of the equation $f(x) = x^2 + 1 = 0$, using the same operational definition of what is meant by solution. The Newton-Raphson operator for this case is such that $|x_{n+1}\rangle = \hat{O}|x_n\rangle$ with $x_{n+1} = (x_n^2 - 1)/(2x_n)$. Here, we assume that our consciousness has only experienced real numbers. A solution to the equation $f(x) = 0$ does not exist on the real axis. However, to demonstrate our point let us say that we cannot grasp other notions
such as the “imaginary” numbers, because we do not have such direct experience. Therefore, let us insist on looking for the solution on the real axis using the Newton-Raphson method. This is meant to parallel the fact of our firm belief, acquired from our macroscopic experience, that every “particle”, while in a state of motion, is also somewhere in space. In addition, this is meant to parallel the fact that these two states are incompatible states of consciousness; namely when the solution is an imaginary number it cannot be placed on the real axis at the same time.

Therefore the Newton-Raphson algorithm, is used here as an “experimental” device to materialize, or operationally apply, or reflect the question, where is the solution to the equation $x^2 = -1$ on the real axis? The incompatibility is that the state $|i \equiv \sqrt{-1}\rangle$ has nothing to do with real numbers. We will find out using our definition of what we mean operationally by a solution to an equation (which also is meant to map our “experimental” operations), that the question, “where is the solution?”, is not a good question. A better question would be, “what is the potential solution?”.

These statements will become clear through this example.

If we iterate for a very long time, we will notice that the method passes many times arbitrarily close to any real number. However, the neighborhood of certain numbers are visited more frequently than others. The probability density of visiting a particular small region near a number $x$ is plotted in Fig. 1 as found by iterating the equation $x_{n+1} = (x_n^2 - 1)/2x_n$ about 200,000 times. Can we give any practical meaning or interpretation to this distribution? We have already paralleled the computerized search for the solution to this equation to the operation of consciousness or an experimental procedure to determine the position of a particle. Let us further assume that this procedure requires a very large number of iterations (such as of the order of the Avogadro number) because each operation of projection (or measurement) in practice is carried out by a macroscopically large number of microscopic processes. Another reason is that since we are accepting as a solution the converged value of this process, we have to carry out a large number of such iterations. If it is applied $10^{23}$ times we will obtain one value of $x$. If we then repeat the procedure by using the same number of iterations, plus one more, then two more and so on, we can obtain different outputs, but they belong to the distribution given in Fig. 1. Therefore in this case we might say that the experimentally determined value of this variable is random but it has a definite probability distribution given by that of Fig. 1.

The operator $\hat{O}$ has no unique inverse because the two operators $\hat{O}_\pm^{-1}|x\rangle = |x \pm \sqrt{x^2 + 1}\rangle$ have the property of the inverse operation, namely $\hat{O}\hat{O}_\pm^{-1} = \hat{1}$. After a large number of iterations $n$ starting from the state $x_0$, the state $\hat{O}^n|x_0\rangle = |x_n = O(O(...O(x_0)...)\rangle$ is not a well-defined output of the procedure because it depends on $n$. However, there is something else which is well-defined as a limit for $n > n_0$, where $n_0 \to \infty$. Let us define the operator

$$\hat{P}_{n_0 \to n} \equiv \sum_{m=n_0}^{n} \hat{O}^m, \quad (53)$$

where $n_0, n$ are numbers of the order of the Avogadro number and $n > n_0$. When
this operator acts on a starting state \(|x\rangle\) the outcome is a distribution

\[ |\psi\rangle = \hat{P}_{n_0 \to n}|x\rangle = \sum_{m=n_0}^{n} |x_{m-n_0} = O(O(...O(x)...))\rangle, \tag{54} \]

and in the last equation, the function \(O(x)\) has been applied \(m-n_0\) times on the value \(x\). The important point is that the state \(|\psi\rangle\), in the limit \(n_0 \to \infty\, n \to \infty\) with \(n = n_0 + m\) and \(m \gg 1\), depends only on the starting value of \(x\). As we will show in the following subsections, the dependence on the value of \(x\) is an overall prefactor, otherwise the normalized state \(|\psi\rangle\) is independent of \(x\).

It is useful to consider the eigenstates of the Newton-Raphson operator \(\hat{O}\) that correspond to the eigenvalue \(\lambda\):

\[ \hat{O}|\nu\rangle = \lambda_{\nu}|\nu\rangle. \tag{55} \]

Let us consider the equation \(O(O...(O(x))...)=x\) where the function \(O(x)\) has been applied \(n\) times. Given a solution \(x = x_0\) to this equation, the following state is an eigenstate of the operator \(\hat{O}\):

\[ |n, x_0\rangle = \frac{1}{\sqrt{n}} \sum_{m=1}^{n-1} \hat{O}^m|x_0\rangle, \tag{56} \]

with corresponding eigenvalue unity. An example of such an eigenstate is \(|2, 1/\sqrt{3}\rangle = 1/\sqrt{2}|1/\sqrt{3}\rangle + |−1/\sqrt{3}\rangle\), because \(O(1/\sqrt{3}) = −1/\sqrt{3}\) and \(O(−1/\sqrt{3}) = 1/\sqrt{3}\).

Fig. 2(a) shows the evolution of the variable \(x\) under the action of the Newton-Raphson operator \(\hat{O}\) starting from the initial value \(x_0 = 1/\sqrt{3}\) for 100 iterations. Notice the cycle \(1/\sqrt{3} \to −1/\sqrt{3} \to 1/\sqrt{3}\) is followed for a few iterations and after that the cycle is broken. The reason is the following. A computer cannot exactly represent the irrational number \(1/\sqrt{3}\) because it only has a limited precision. Therefore it starts from the neighborhood of that number (the truncation of the number, say up to ten significant digit accuracy) but a few iterations later the value of \(x_n = \hat{O}^n x_0\) is very far from the original solution corresponding to the cycle of period 2, because of the propagated error. In fact after a few iterations the value of the \(x_n\) is closer to a member belonging to a different cycle of period \(m\). If the period \(m\) is a large integer, because of the limited precision before the end of even one cycle, we get closer to another cycle and so on. Figs. 2(b-c) give the evolution of the variable \(x\) within 1000 and 10000 iterations. The distribution of \(x\) after 200000 iterations is shown in Fig. 1 where it is compared with the Lorentzian (which is the exact solution, see Eq. \(57\)).

Eigenstates corresponding to an infinite cycle (continuum) are of the following form

\[ \psi_{\nu}(y) = \frac{\phi_{\nu}(O(y))}{y^2 + 1}, \quad \phi_{\nu}(y) = \lambda_{\nu}\phi_{\nu}(O(y)). \tag{57} \]

An obvious solution to the second equation is the constant which implies \(\psi_1(y) = 1/\pi(y^2 + 1)\) with eigenvalue \(\lambda = 1\). This is shown by the solid line in Fig. 1 which
fits very well the results of the numerically implemented Newton-Raphson method. The other solutions of the above equation are not going to be discussed because this goes beyond the goal of this work.

In the limit of \( n_0 \to \infty \) and \( n - n_0 \to \infty \) the projection operator takes the form

\[
\hat{P}_{n_0 \to n} |x\rangle = c \sum_{\mu; \lambda=1} \langle \mu|x\rangle |\mu\rangle \quad c = n - n_0.
\]

The question is why is the probability density to observe a definite value of \( x \), \( |\psi(x)|^2 \), and not \( \psi(x) \)? In order to measure the probability to find the value \( x \) we need to start the projection process at \( x \) and measure it at \( x \) or another place \( x' \). The “particle” is not on the real axis, we just believe it must be. We also know that it can be on the real axis in the sense defined by the operational definition or by our way of searching. There is no “particle” anywhere on the real axis unless we start the operational procedure which defines it, in quantum mechanics this means the experimental procedure. Therefore, particles do not exist on our perception screen on their own, the act of observation creates them. We need to start the measuring or projection process from some value of \( x \) and ask the question what is the probability to observe the “shadow” of the particle at \( x \). Our procedure implies that we will measure the ratio of the number of occurrences of the particle at \( x \) (or between \( x \) and \( x + dx \)) to the total number of measurements \( n - n_0 \). This implies that the probability is proportional to \( P(x) \propto \langle x|\hat{P}_{n_0 \to n}|x\rangle \). In the limit of large \( n \) we find

\[
P(x) \propto \sum_{\nu; \lambda=1} |\psi_\nu(x)|^2,
\]

and this agrees with what we know from the quantum mechanical measurement process.

### 10.2 “Quantum” Interference

Let us see how far we can push this analogy with quantum mechanics. One of the most important aspects of quantum theory is the so called interference. The two-slit thought experiment is the best known formulation of the problem. Here we will consider the case of the equation \( f(x) = 0 \) with \( f(x) = (x^2 + \delta)((x - 3)^2 + \delta) \). While there are two independent sets of solution one with real part equal to zero, as before, and another with real part equal to 3, our “measurement” (or projection) process gives interference.

First we choose a small value of \( \delta = 0.01 \), and when we apply the Newton-Raphson projection algorithm, we find the distribution shown in Fig. 3 (Left graph). There are two Lorentzian peaks near the real parts of the solutions, namely \( x = 0 \) and \( x = 3 \) and the widths of these Lorentzian distributions are of the order of the imaginary part, namely 0.1. Notice that because of the small width of these two distributions, there is negligible overlap and the “particle” seems to be either around \( x = 0 \) or around \( x = 3 \). In the right graph of Fig. 3 the distribution obtained from the same projection process for \( \delta = 0.1 \) (dashed line) and \( \delta = 1 \) (solid line). Notice
that as the widths of the two distributions become broader, interference peaks begin to appear. They correspond to values of $x$ which form cycles but they arise from bounces off both neighborhoods, namely, the $x = 0$ and the $x = 3$ neighborhood. Since the actual “particle” is either at $x = 0 \pm i\sqrt{\delta}$ or $x = 3 \pm i\sqrt{\delta}$ and nowhere on the real axis, its “shadow” on the real axis, which is what we observe (because of our insistence of asking the wrong question), appear to be in both places at once and to interfere.

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[23] Aristotle, *Posterior Analytics* II 19, 99b28-29: ‘εί δέ λαμβάνομεν μή ἔχοντες πρότερον, πώς ἂν γνωρίζομεν καὶ μανθάνομεν εκ μὴ προϋπαρχούσης γνώσεως.’

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[28] The idea of something “potentially existing” was discussed by Aristotle, see, e.g., *Physics*, 186a1-3. ‘... ἣς τὸ τὸ καὶ ἔνδυναμες ἐν τῇ ἐντελεχείᾳ.’ This can be translated as follows: ‘... because the one exists in potentia and in actuality.’

[29] Parmenides, *On Nature*, Pre-Socratic Greek Philosopher, born in 510 B.C. See *The fragments of Parmenides*, A. H. Coxon, (Assen, Netherlands, 1986). See also Ref. 30.

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We postulate that the seat of consciousness cannot be matter-energy itself because matter is itself an experience of consciousness; namely the experience of matter is given us \textit{posteriori} but \textit{that} which perceives matter, that which has the experience, must be ready for the experience to occur \textit{a priori}\textsuperscript{[24]}. 

E. Webb, \textit{Philosophers of Consciousness}, Chapter 2, “B. Lonergan, Consciousness as experience and operation”, pg. 53 (University of Washington Press, Seattle, 1988).

The original meaning of the Greek word “phenomenon” is “appearance”, namely, that which appears in consciousness.

When a sentient being is examined to study “his” consciousness using all presently available instrumentation, the being is turned into an object (See Ref. [14], Chapter 3, “The principle of objectivation”). Subject is the experience of oneself. For example, if we follow the nerve excitation caused by the molecules of a flower which interact with those of his nose we will never “see” or experience the aroma. All we will be able to see is the electromagnetic imprint, the pointer which ultimately the subject experiences. Some people are inclined to think that this is not the final stage, that somehow another part of the brain has looked at this imprint and interpreted it. However, we have already included this, namely, the imprint we are considering is the one produced in the brain after this process, namely, it is the collective neural excitations including the neurons that process all the series of signals and their translations to other signals. See also, Ref. [14], Chapter 6, “The mystery of the sensual qualities”.

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Figure Captions

Fig. 1: The distribution of the steps of the Newton-Raphson iteration process to solve the equation $x^2 = -1$ within the real axis. This is also an eigenstate of the Newton-Raphson operator as defined by Eq. 52 with eigenvalue unity.

Fig. 2: The evolution of the variable $x$ under the action of the Newton-Raphson operator to observe the solution of Eq. 52 starting from the initial value $x_0 = 1/\sqrt{3}$.

Fig. 3: Demonstration of interference. Left graph is obtained for $\delta = 0.01$. Right graph: for $\delta = 0.1$ (dashed line) and $\delta = 1$ (solid line).
Figure 1:
Figure 2:
Figure 3: