Article

Quantum Information Theory Applied to Unconscious and Consciousness

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ABSTRACT

In this paper we make some comments about notions we already introduced in previous articles. First we further study the quantum field model of consciousness and unconscious built up together with Belal Baaquie and show that it is a quantum formulation of the layered model of the Collective Unconscious established by C. G. Jung in 1925. Then we further study quantum information and quantum cloning in order to apply them to amplification of unconscious components in such a way that they reach consciousness. After that, we study consciousness and its special feature when it consists in awareness of unconscious states. This leads us to examine if Archetypes could be quantum systems. In conclusion, we list various points of view about the essence of consciousness. The fact that quantum entanglement is "controlled" from *outside space-time* leads to the conclusion that consciousness would be an entity which acts from *outside space-time*.

Key Words: psychophysics, archetypes, consciousness, unconscious, quantum information

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1. Introduction

As Jung said in his conference at a symposium in London in 1919 (Jung, 1970): "The archetypes are being *engraved on the human mind*". Hogenson in his paper (Hogenson, 2001) argues that "This latter expression is taken by some commentators to be indicative of Lamarckian tendencies in Jung's thought" (Stevens, 1990; Stevens, 1998; Stevens and Price, 1996). This Jung's sentence correlates the experience into our psychic constitution as form without content: "There are as many archetypes as there are typical situations in life. Endless repetition has engraved these experiences into our psychic constitution, not in the form of images filled with content, but at first only as form without content, representing merely the possibility of a certain type of perception and action" (Jung, 1959). However, following Hogenson, Jung was interested in the evolutionary history of the mind with no implied commitment to any particular theory of evolution.

Although Darwin (1809-1882) disliked the association between his theory and the theory of Lamarck (1744-1829), we have to remember that the work of Gregor Mendel was rediscovered only in 1900.

To say that the appearance and evolution of archetypes is explained by the evolution theory does not mean that we know where archetypes are "stored" (In the brain? Are they coded by the DNA? Will we find a "gene of the archetype"?). Moreover one should also explain how the archetypes constitute an "evolutionary advantage" that has been selected and preserved. Moreover, even advocating evolutionary theory, we still find a fundamental difference between archetypes and, for instance, language. Human languages have diverged over the course of centuries, while archetypes have remained substantially invariant across time and space.

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Could we say that they belong to the realm of Platonic ideas?

In 1925, Carl G. Jung had the idea of a kind of geological survey of the psyche (Jung, 1925). Jung's description of the geology of the psyche is shown on Figure 1.

At the basis of the psyche there is what Jung called the central fire (H).[2] Then there is the layer corresponding to general animal ancestors (G), the layer corresponding to primitive ancestors (F), the layer corresponding to large groups, such as Europeans (E), the layers corresponding to nations (D), to clans (C), to families (B) and to finish an individual psyche appears. In Jung's sketch of the psyche, ego, or consciousness of an individual, appears as a peak. The personal unconscious underlies it. Next, the Collective Unconscious (Jung, 1961; 1991), starting from the family's unconscious until the animal ancestors (or even until the beginning of life), underlies the personal unconscious. At the bottom of all things, or at the beginning of all things, there is the central fire (or quantum vacuum).

An original property of Jung's vision of the human psyche is that the central fire is directly connected to the individual's unconscious. The central fire permeates every layers of the Collective Unconscious and comes right up to the personal unconscious if we let it do it. The vacuum or the central fire containing all the seeds of all archetypes, this means that we can have direct access to archetypes. This direct access of an individual's unconscious to the vacuum, or the central fire, can explain some kind of dreams, especially archetypal dreams (such as Pauli's dreams). It may also explain some a-causal events such as synchronicity effects. We can assert that an individual unconscious "knows everything", in the sense that any individual unconscious has access to any information in the Universe. This does not mean that this information will necessarily reach the consciousness of any individual.

In 2003, Baaquie and Martin (2005) rediscovered this Jung's geological survey model of the psyche in the framework of quantum field theory. In particle physics we postulate the existence of quantum fields associated to each elementary particle. Those fields are operators defined in all space-time and acting on states, vectors of a Hilbert space, corresponding to the wave function of a set of particles. A quantum field associated to a particle is the sum of a creation operator of the particle together with an annihilation operator of the particle. Thus the creation operator acting on the quantum vacuum $|\Omega\rangle$ creates a state of the particle. The quantum vacuum contains all the quantum fields in a virtual state, i.e., none of the normal modes of the fields are excited in the vacuum, although they are virtually present.

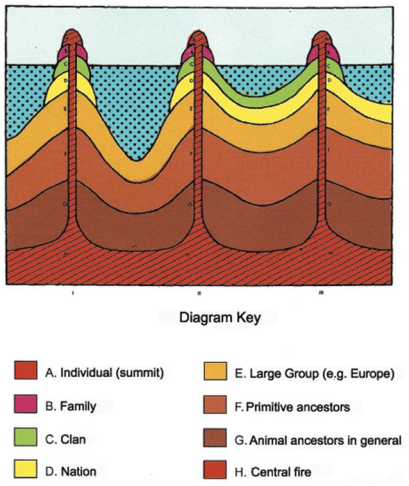

Figure 1. Jung's volcanoes diagram.

Baaquie and Martin postulated that, like matter, mental states and human consciousness (and unconscious) would be of quantum nature. Thus they assume that the human psyche would be a particular excitation of an underlying universal mental (unconscious and consciousness) quantum field[3]. The human psyche is postulated to have a representation similar to a quantum system, with virtual and physical states corresponding to the potentiality and actuality of the human mind.

To describe the human psyche they suppose the existence of two kinds of quantum fields, namely one that refers to the specific individuality of the person, and which should be more or less localized with the person's specific existence and excludes other person's individual quantum field. The other quantum field represents the universality of the human psyche, which can overlap and include other's consciousness. It is natural to represent the individualized state of the human psyche by a

[2] Later we will see that this central fire may be what physicists call the quantum vacuum.

[3] In the following when we will refer to a quantum field of consciousness it will necessarily include the unconscious.

fermion field $\psi(t,x)$ and the universal character of human consciousness by a boson field $\varphi(t,x)$, where t, x are time and space coordinates.

As physicists try to unify all quantum fields of matter in a unique quantum field, we can try to unify the consciousness fields $\psi(t,x)$ and $\varphi(t,x)$ described above with this (possible) unique quantum field of matter and obtain a unique quantum field describing both matter and mind. In this way we will approach the holistic reality, the *Unus Mundus*, the "one world" of the 16th century alchemist Gerhard Dorn. This *Unus Mundus* was advocated by Jung and Pauli as the underlying reality in which mind and matter are unseparated. The "consciousness field" was separated from the unique quantum field of matter at the beginning of the Universe, but both fields remained quantum entangled. This happened when space-time was generated, i.e., at time $t = 10^{-43}$ second, which is Planck's time, after the Big Bang. Of course, at that time, the individual centred consciousness field was zero together with all the boson fields $\varphi_i(t,x)$ associated with each layers of Jung's volcanoes diagram (from B to G; see Figure 1). But all the seeds of those quantum fields, together with the seeds of archetypes, were present in the vacuum or the central fire (Figure 1).

However there are some problems. First, how did space-time emerge from this *Unus Mundus*, which could be the quantum vacuum or the central fire of Jung? Second, for Jung, the psyche is timeless and spaceless, i.e., it has its roots beyond space-time. But we already know that even in relativistic quantum field of matter there are some problems with space-time, especially in quantum gravity. Moreover we know that quantum entanglement transcends our notions of space and time (Caponigro, 2009). As far as matter and psyche are concerned, prior to any measurement, quantum correlations due to quantum entanglement are relevant to what David Bohm calls the *implicate* (or *enfolded*) order, which is beyond space-time, unlike the *explicate* (or *unfolded*) order which describes the phenomena that are manifest to our senses (consciousness) and to our instruments (Bohm, 1980). The implicate (or enfolded) order is in an undivided (or *unfragmented*) form, while the explicate (or unfolded) is in a *fragmented* form. In the implicate order, mind and matter are unseparated (non-separable) entities.

For a lot (but not all; see for example references Eccles, 1994; Beck and Eccles, 1998) of neuroscientists, consciousness, pre- and un-consciousness are simply processes measuring dynamical complexity in the neural systems underlying consciousness: e.g., neural complexity, information integration and causal density (see Seth, Izhikevich, Reeke and Edelman, 2006).

At the beginning of his article, "*Synchronicity, Mind and Matter*" (Duch, 2003), W. Duch quotes, as a motto, a sentence of Pauli: "It would be most satisfactory if physics and psyche could be seen as complementary aspects of the same reality" (Jung and Pauli, 1952). Complementarity is the fact that two properties of a system are contradictory but nevertheless coexist in the system and appear depending on the kind of experiment we perform on the system. The best example is the wave aspect and the corpuscular aspect of matter.

In their paper Baaquie and Martin (2005) propose a simplified model for the ground state of the human species. This ground state $|G(T)\rangle$ represents the total sum (or rather the total product) of all the excitations on the vacuum state $|\Omega\rangle$ of the "consciousness field" that has been effected by human subjectivity over the entire period of human evolution. It is on this ground state that the present day psyche of human beings is standing, and the entire theoretical structure that we are born into is encoded in the ground state $|G(T)\rangle = |G\rangle$, where T stands for our contemporary time. Let us notice that this ground state $|G(T)\rangle = |G\rangle$ is an unconscious state[4], and that it has a structure close to what the Swiss psychoanalyst C. G. Jung called the Collective Unconscious.

Then, starting from this ground state of the human species and taking account of the contributions of the mother, the father, and all the siblings, the grandparents and uncles and aunts and first cousins and so on, Baaquie and Martin built a family effective ground state[5]

[4] From which some components can come to consciousness
[5] Which is still an unconscious state, from which some components can come to consciousness.

$|G_{Effectif}\rangle$ on which we can create an individual's ground state[6] together with the individual's mental states, which can be either unconscious or conscious.

In their paper they wrote: "What is our interpretation of the vacuum state $|\Omega\rangle$? It contains the seeds of all possible forms of subjectivity and consciousness that can exist in the Universe – be it human consciousness (and unconscious), or the consciousness of animals, or that of other alien species in some other planet. It is the state of possibility of all the psychic qualities and attributes of the Universe, all the laws and structure of the physical Universe." If we follow Jung the vacuum should also contain the seeds of all archetypes. Let us notice that we have a unique vacuum both for matter and for the psyche.

Baaquie and Martin's model is a layered model starting from the vacuum in which the various layers are generated by creation operators, i.e., mental fields. Thus there is a layer corresponding to life, another one corresponding to animals, then one corresponding to the human species, another one corresponding to a family until we reach the consciousness (and unconscious) of one individual belonging to that family.

How can we insert this direct connection between the vacuum and an individual's unconscious in a quantum field theory of the psyche? It could be similar to what happens in quantum field theory of matter in which vacuum permeates all space-time and all matter, leading to processes such as vacuum fluctuations which lead to observable, finite physical effects, e.g., in the Lamb shift.

To each layer of Jung's volcanoes diagram (from B to G) we can associate a boson field $\varphi_i(t,x)$ which is included in the Impersonal (general) "consciousness" field $\varphi(t,x)$ described above (which includes the unconscious) and which represents the Collective Unconscious. In conclusion, we can say that Baaquie and Martin (2005) have drawn up a quantum interpretation, in terms of quantum fields, of Jung's layered model of the Collective Unconscious. But they have done more than this, in the way that they have considered that the existence of a universal quantum field of "consciousness"[7] could represent not only the Collective Unconscious but also a universal consciousness or awareness. The metaphor would be the one of a universal ocean of consciousness in which an individual consciousness would be like a wave that comes out of the ocean and eventually returns to the ocean.

In 2007, Carminati and Martin (2008; Martin and Galli Carminati, 2009) studied the individual unconscious and consciousness as quantum systems, i.e., as vectors of a Hilbert space. In such a frame they studied the phenomenon of consciousness and especially the awareness of unconscious components. Writing down the state of the unconscious as $|U\rangle$ and the state of consciousness as $|C\rangle$, they introduced another state of the unconscious $|I\rangle$ which is the insight or pre-consciousness[8]. By building a model of quantum entanglement between those three states they apply it to the awareness of unconscious components.

In 2009 we took the theory of quantum information as a model for the psyche (Martin, Carminati, Galli Carminati, 2009; 2010). We considered the individual human unconscious, pre-consciousness and consciousness as sets of quantum bits (qubits). We viewed how there can be communication between these various qubit sets. In doing this we were inspired by the theory of nuclear magnetic resonance (NMR). In this way we built a model of handling a mental qubit with the help of pulses of a mental field. Starting with an elementary interaction between two qubits we built two-qubit quantum logic gates that allow information to be transferred from one qubit to the other. In this manner we built a quantum process that permits consciousness to "read" the unconscious and vice versa. The elementary interaction, e.g., between a pre-consciousness qubit and a consciousness one, allows us to predict the time evolution of the pre-consciousness + consciousness system in which pre-consciousness and consciousness are quantum entangled. *This time evolution exhibits Rabi oscillations that we named*

[6] Same as Footnote 5.

[7] See Footnote 3.

[8] In this article we will consider the insight states $|I\rangle$ and the pre-consciousness states $|P\rangle$ as different quantum states. Insight, which designates also perspicacity or intuition, is different from pre-consciousness which designates those quantum states which are "close" to consciousness. Latter in this article we will use insight as an ancilla or cloning machine M.

mental Rabi oscillations. This time evolution shows how for example the unconscious can influence consciousness. In a process like mourning the influence of the unconscious on consciousness, as the influence of consciousness on the unconscious, are in agreement with what is observed in psychiatry.

In Section 2 of this article we remind one of our representation of mental qubits and of quantum psyche fields built by analogy with spin-qubits and magnetic fields in NMR. In Section 3, still by analogy with NMR, we remember how to rotate a mental qubit on the Bloch's sphere by a pulse of a quantum psyche field with could be the quantum field of consciousness (volition), or of the individual unconscious, or of Jung's Collective Unconscious (archetypes), or even a quantum field of someone else's unconscious (e.g., in the framework of psychoanalysis). In Section 4 we describe the three main types of contact interactions between two qubits, which are used in quantum information and could be applied to mental qubits. Then we remind one of the implementation of controlled-NOT (CNOT) two-qubit quantum gate which leads to *quantum entanglement* and to *non-separable* qubit systems. Due to a basic theorem of quantum computation which states that any unitary transformation on a two-qubit system can be factorized into a CNOT gate and rotations described in Section 3, we can build quantum circuits with any number of qubits. Therefore we can build *non-separable* qubit systems with any number of qubits. In Section 5 we consider quantum cloning. There is a *no-cloning theorem*, due to Wootters and Zurek (1982), which prevents to duplicate perfectly an arbitrary quantum state. However it is possible to make an approximate quantum cloning which could be optimal. In quantum optics, using (approximate) quantum cloning, it is possible to amplify a quantum state in an optimal way. By analogy, we speculate that it is an approximate process of quantum cloning which amplifies the information contained in the unconscious. The *quantum no-cloning theorem* could explain why, for example, the information contained in a dream is transformed during the process of amplification before reaching consciousness. This is quite important since "dreams are the royal road which leads to the unconscious" (Freud, 1920).

In Section 6 we consider consciousness and its various forms. First we study perceptive consciousness (subsection 6.a). In a normal state of awake consciousness, our sensor senses comprehend a "*classical*" external world, i.e., a world without superposition of states. But, as far as our internal world (mental states) is concerned (subsection 6.b), we show that our consciousness can comprehend a quantum world, with "pointer-states" (i.e., *classical* states, Zurek, 2007) together with interferences between them (i.e., superposition of mental states). In the same line of thought, we point out another difference between physical and mental states: If, in order to become *classical, quantum* physical states may be subjected to collapse of the wave function (or reduction of the wave packet),- a fact which is far to have unanimous support from physicists -, there is no such process for quantum mental states. A mental state can become conscious without any collapse of the wave function, i.e. without destroying the superposition of mental states, a phenomenon which fits with Everett's "Relative State" or "many-worlds" theory (Everett, 1957; Wheeler 1957). In continuation of those ideas, we study awareness of unconscious states (subsection 6.c). We put the emphasis on the fact that if, for physical states, decoherence (interaction with the environment) is of paramount importance in the transition from *quantum* to *classical*, there is no such process like decoherence in the realization of unconscious states (subsection 6.d).

In Section 7 we consider Archetypes which are, according to C. G. Jung (1971: page 167), basic entities of the deep Collective Unconscious. We tell apart Archetypes (with a big A) and archetypes (with a small a). We call them Archetypes, with a big A, when they are "*empty of form*", i.e., empty of any representation. In this instance they are quantum systems which simply contain quantum information. They could be quanta of the Universal Unconscious Quantum Field. The interaction of those Archetypes with an individual unconscious (especially with memory states) and also with some parts of the Collective Unconscious (especially the collective memory states of the human species) will make appear archetypes (with a small a) which will be representations of the Archetypes. Those archetypes can be considered as "pointer-states" of the unconscious, but of a very special kind. Contrarily to what occurs in quantum physics,

these archetypal "pointer-states" of the unconscious coexist in the same representation, in the same archetype. In this way archetypes are conjunctions of opposites. They cannot be considered as *classical*, they remain *quantum*. We give some examples of archetypes: "young and old woman" (Figure 6), Rebis (Figure 7), representation of Shiva (Figure 8).

Then we make some comments about mathematics considered as Archetypes (subsection 7.1). Finally our conclusions are given in Section 8.

2. Quantum information theory: qubits

In his paper "World as system self-synthesized by quantum networking" J. A. Wheeler (1988) sees the world as a "self-synthesizing system of existences, built on observer-participancy via a network of elementary quantum phenomena. The elementary quantum phenomena in the sense of Bohr, the elementary act of observer-participancy, develops definiteness out of indeterminism, secures a communicable reply in response to a well-defined question." To such a well-defined question there is a yes or no answer. For example the no answer will be represented by the state $|0\rangle$ and the yes answer by the state $|1\rangle$. The elementary quantum state will be a qubit (quantum bit) which is a superposition of the states $|0\rangle$ and $|1\rangle$:

$$|\Psi\rangle = e^{-i\phi/2}\cos(\theta/2)|0\rangle + e^{i\phi/2}\sin(\theta/2)|1\rangle \qquad (1)$$

This qubit is represented by a vector on the Bloch's sphere (Figure 2).

In references (Galli Carminati and Martin, 2008; Martin and Galli Carminati, 2007; Martin, Carminati and Galli Carminati 2009; 2010) we have represented the unconscious of a person in a mourning process by the qubit:

$$|U\rangle = e^{-i\phi/2}\cos(\theta/2)|U0\rangle + e^{i\phi/2}\sin(\theta/2)|U1\rangle \qquad (2)$$

where $|U0\rangle$ is the state corresponding to a mourning that is accomplished and $|U1\rangle$ the state corresponding to a mourning that is not achieved. Let us notice that the qubit $|U\rangle$ has to be multiplied by a function $f_U(\vec{x},t)$ which is the probability amplitude of finding the qubit $|U\rangle$ at the space-time point $(\vec{x},t)$. For an individual unconscious qubit this probability amplitude is more or less located in the body of the individual, especially in his brain.

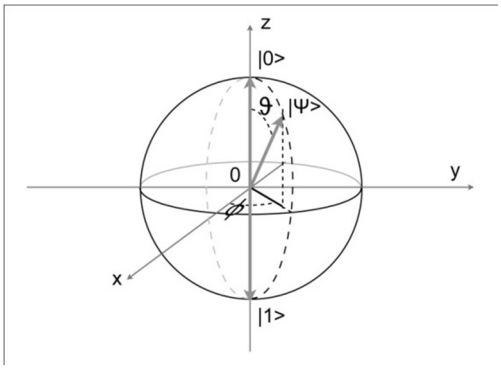

Figure 2. Bloch's sphere which enables to represent the qubit $|\Psi\rangle$ by a vector of polar angles θ and φ.

By analogy with the theory of nuclear magnetic resonance (NMR) we assume that there is a psyche mental field $\vec{B}_{U0}$ which points toward the direction of the qubit $|0\rangle$, i.e., toward the direction of the *Oz* axis on the Bloch's sphere. This psyche mental field $\vec{B}_{U0}$ is the analogue of the magnetic field $\vec{B}_0$ in NMR (Martin, Carminati and Galli Carminati, 2010; Vandersypen and Chuang, 2004). It has a space-time dependence, i.e., it depends on the space-time point $(\vec{x},t)$, and it can be a quantum field which means that since it points along the *Oz* axis it is a quantum field of which creation operator of a field quantum is proportional to the Pauli matrix σ_z.

Let us notice that the axes *Ox, Oy* and *Oz* of the Bloch's sphere are not space axes, since the Bloch's sphere is not a sphere in space but in the Hilbert space of the qubit. *Oz* axis direction is nothing else but the pointer-state directions $|U0\rangle$ (*e.g.,* father is dead) and $|U1\rangle$ (*e.g.,* father is alive). So the psyche field $\vec{B}_{U0}$ that "selects" this direction is a field related to the external reality and consequently to the environment. It is a quantum psyche field which has its roots in the external reality, in the environment. It measures the relation of the individual unconscious and consciousness with external reality.

Let us also notice that this psyche field $\vec{B}_{U0}$ that "selects" the pointer- states direction could also be a field related to the Collective Unconscious and more specifically to archetypes. As an example the archetype of

"Eternity" will select the pointer-state $|U1\rangle$ (father is alive and never dies) in the unconscious. If the father is really dead, this unconscious state $|U1\rangle$ will be in contradiction with the state of consciousness $|Co\rangle$ (father is dead).[9]

3. Rotation of a qubit

The basic logical quantum gates acting on only one qubit are rotations on the Bloch's sphere. The most general rotation of angle θ_1 around an axis defined by the unitary vector $\vec{n} = n_x\vec{e}_x + n_y\vec{e}_y + n_z\vec{e}_z$ on the Bloch's sphere is implemented by the operator:

$$R_{\vec{n}}(\theta_1) = \exp[-i\theta_1\vec{n}\cdot\vec{\sigma}/2] \qquad (3)$$

where $\vec{\sigma} = \sigma_x\vec{e}_x + \sigma_y\vec{e}_y + \sigma_z\vec{e}_z$ is a Pauli matrix vector.

In reference (Martin, Carminati and Galli Carminati, 2010), still by analogy with NMR, we showed that any rotation (3) of a qubit on the Bloch's sphere can be implemented by a pulse of a psyche field $\vec{B}_{U0}$ "along the *Oz* axis", together with a radio-frequency pulse (RF pulse) in the (*Ox, Oy*) plane. Such a radio-frequency pulse is the pulse of a psyche field $\vec{B}_{U1}(t)$ (analogue to an electromagnetic field) which rotates in the (*Ox, Oy*) plane with frequency $\omega_{rf}/2\pi$, this frequency being equal or close to the Larmor frequency $\omega_0/2\pi$.[10,11] When the rotating frequency $\omega_{rf} = \omega_0$ (resonance), such a RF pulse is called a Rabi pulse.

For a mental qubit representing mourning (formula (2)), or for any binary mental state, a pulse of a psyche field "along the *Oz* axis", $\vec{B}_{U0}$, modifies the ϕ angle without modifying the θ angle, a fact which is not very interesting concerning the evolution of mourning, this one being "measured" by the variation of the θ angle.

By contrast a psyche field pulse "rotating in the (*Ox, Oy*) plane", $\vec{B}_{U1}(t)$, will modify the θ angle and therefore will make mourning evolve. For simplicity let us assume that the ϕ angle is equal to 0. Therefore in such a case a psyche field pulse pointing along the *Oy* axis will modify the θ angle by a quantity proportional to the duration t_p of the pulse. Effectively, in order for mourning to evolve in the "good" way, i.e., that the θ angle tends toward 0, it is necessary for the psyche field to point along the direction $-Oy$.

We have seen that the quantum psyche field, $\vec{B}_{U0}$, has its roots either in the external reality, in the environment, - it measures the relation of the individual unconscious and consciousness with external reality - , or in the Collective Unconscious (archetypes). What about the rotating quantum psyche field, $\vec{B}_{U1}(t)$? It could be a quantum field of consciousness (the will) or of the individual unconscious, e.g., of Freud's Id, Repressed, Ego and Super-ego, or of Jung's Persona, Shadow and Oneself. It could also be a quantum field of the Collective Unconscious (archetypes) or a quantum field of someone else's unconscious (e.g., in the framework of psychoanalysis).

4. Interaction between two qubits

In reference (Martin, Carminati and Galli Carminati, 2010) we have studied the effect of a contact interaction between two qubits of which the Hamiltonian is:

$$H_J = hJ\vec{I}^1 \otimes \vec{I}^2 \qquad (4)$$

where $\vec{I}^1 = \vec{I}^1_x\vec{e}_x + \vec{I}^1_y\vec{e}_y + \vec{I}^1_z\vec{e}_z = \vec{\sigma}^1/2$, $\vec{\sigma}^1$ being the Pauli matrix vector acting on qubit 1. The same is true for $\vec{I}^2 = \vec{\sigma}^2/2$, which concerns qubit 2. This is the Hamiltonian of an isotropic Heisenberg exchange interaction. It appears mainly in solid-state quantum information. The J constant is the coupling strength between the two qubits.[12]

[9] See Special case I (Subsection 5.1.1) in reference (Martin, Carminati and Galli Carminati, 2010)

[10] For a definition of the Larmor frequency $\omega_0/2\pi$, see reference (Martin, Carminati and Galli Carminati, 2010).

[11] On a quantum point of view a psyche field "located in the (*Ox, Oy*) plane" is a field of which field quanta creation and annihilation operators respectively create and annihilate the quantum states $|0\rangle$ and $|1\rangle$. Such operators are proportional to the operators $\sigma_+ = (\sigma_x + i\sigma_y)/2$ and $\sigma_- = (\sigma_x - i\sigma_y)/2$, where σ_x and σ_y are Pauli matrices.

[12] The fact that Planck's constant *h* appears in a Hamiltonian supposed to describe a mental process looks meaningless, this constant being involved *a priori* only in microscopic matter processes. Moreover until proved otherwise we have not clearly define what is mental energy. However that may be, in Schrödinger's equation or in the time evolution operator *U(t)*, only the operator *H/h* takes place. Therefore Planck's constant does not appear in quantities that interest us, i.e. the time evolution operators. Let us notice that,

The symbol $\otimes$ represents the tensor product of the two operators $\vec{I}^1$ and $\vec{I}^2$ which acts in the space tensor product of the two Hilbert spaces of qubits 1 and 2. By using the relation between the angular momentum operator vector and the Pauli matrix vector we obtain the formula:

$$\vec{I}^1 \otimes \vec{I}^2 = \left(\sigma_x^1 \otimes \sigma_x^2 + \sigma_y^1 \otimes \sigma_y^2 + \sigma_z^1 \otimes \sigma_z^2\right)/4 \qquad (5)$$

In NMR, for nuclear spins in a static magnetic field $\vec{B}_0$ along the *Oz* axis, and under some conditions, the Hamiltonian (4) simplifies to:

$$H'_J = hJI_z^1 \otimes I_z^2 \qquad (6)$$

which is known as the Hamiltonian of a secular interaction.

In reference (Martin, Carminati and Galli Carminati, 2010), we have also assumed that in the presence of the quantum psyche field $\vec{B}_{U0}$, the interaction Hamiltonian (4) simplifies to the Hamiltonian (6). The interaction Hamiltonian (6) proves very useful to implement logical two-qubit gates.

There is a third Hamiltonian of a "contact type" interaction between two qubits, known as the flip-flop interaction:

$$\begin{aligned} H''_J &= hJ\left(\sigma_x^1 \otimes \sigma_x^2 + \sigma_y^1 \otimes \sigma_y^2\right)/4 \\ &= hJ\left(\sigma_+^1 \otimes \sigma_-^2 + \sigma_-^1 \otimes \sigma_+^2\right)/2 \end{aligned} \qquad (7)$$

This last interaction leads to Rabi oscillations of frequency J.

4.1 Implementation of two-qubit logical quantum gates

The basic two-qubit logical quantum gate is the controlled-NOT (CNOT) gate. In the basis $|00\rangle$, $|01\rangle$, $|10\rangle$ and $|11\rangle$ in which the first index refers to qubit 1, whereas the second one refers to qubit 2, this gate is represented by the matrix:

$$U_{CNOT} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{pmatrix} \qquad (8)$$

The matrix notation of base qubits $|00\rangle$, $|01\rangle$, $|10\rangle$ and $|11\rangle$ is the following:

$$|00\rangle = \begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \end{pmatrix} \quad |01\rangle = \begin{pmatrix} 0 \\ 1 \\ 0 \\ 0 \end{pmatrix} \quad |10\rangle = \begin{pmatrix} 0 \\ 0 \\ 1 \\ 0 \end{pmatrix} \quad |11\rangle = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1 \end{pmatrix} \qquad (9)$$

The U_{CNOT} transformation flips qubit 2 (target qubit) if and only if the quantum state of qubit 1 (control qubit) is $|1\rangle$ (Figure 3).

In the following we will represent the CNOT gates by the diagram of Figure 4. A basic theorem of quantum computation states that up to an irrelevant overall phase, any unitary transformation U acting on two qubits can be factorized into a U_{CNOT} gate and rotations $R_{\vec{n}}(\theta_1)$ acting on each of the two qubits (Nielsen and Chuang, 2000).

By analogy with NMR, in reference (Martin, Carminati and Galli Carminati, 2010) thanks to the interaction (6) acting between the two qubits during a given time $t = 1/2J$, and thanks to radio-frequency pulses acting on each of the two qubits also during a given time, we are able to implement a CNOT gate between two qubits and therefore to implement any unitary transformation on a two-qubit system.

Usually, if initially the system of the two qubits is in a factorized state $|\Psi_1\rangle|\Psi_2\rangle$, after going through the CNOT12 gate, the state of the two-qubit system will be *non-separable*. The two qubits will be quantum entangled.

In reference (Martin, Carminati and Galli Carminati, 2010), we saw that the product of the three CNOT gates: CNOT12 CNOT21 CNOT12 exchanges the states of qubits 1 and 2. It is a swapping of the states of qubits 1 and 2.

Knowing that any unitary transformation U acting on two qubits can be factorized into a U_{CNOT} gate and rotations $R_{\vec{n}}(\theta_1)$ acting on each of the two qubits we can build quantum circuits with any number of qubits. An example of such a circuit is given on Figure 5 (Haroche, 2010; Buzek and Hillery 1996; Scarani *et al.*, 2005).[13]

according to Lotka (1925; Vannini, 2008), Planck's constant could intervene in the phenomenon of emergence of (subjective) consciousness.

[13] This Figure is excerpted from Serge Haroche's Quantum Physics Lesson of February 1st 2010 (Haroche, 2010).

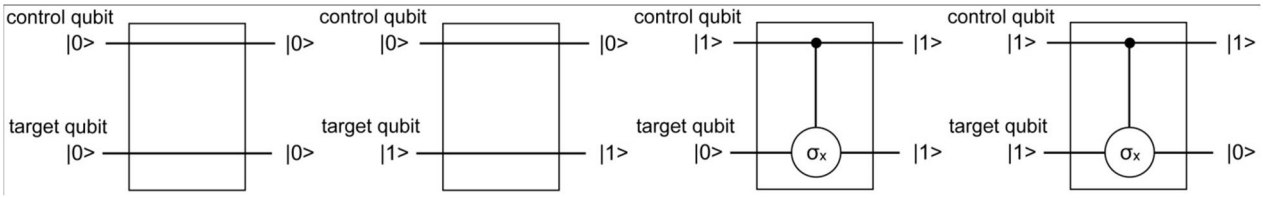

Figure 3. Representation of the $CNOT_{12}$ gate for base qubits (see formula 9).

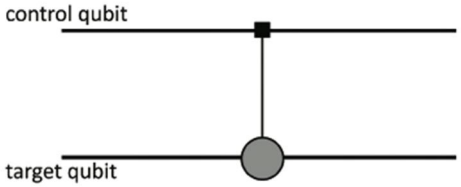

Figure 4. Schematic representation of a CNOT gate.

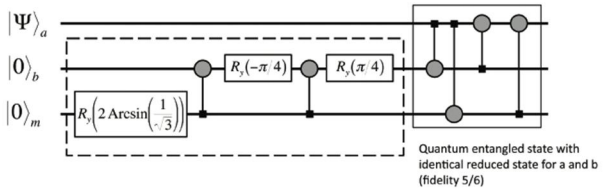

Figure 5. Circuit of optimal cloning.

Let us notice that a circuit of qubits looks like a Feynman diagram. In the circuit of optimal cloning represented on Figure 5 the qubit $|o\rangle_m$ acts as an ancilla. In references (Galli Carminati and Martin, 2008; Martin and Galli Carminati 2007; Martin, Carminati and Galli Carminati 2010) we have used the insight, which allows ideas to reach our consciousness, as an ancilla. We considered it as a preconscious quantum system that we designated by the qubit $|I\rangle$ in the case of mourning. Let us notice that in this paper we will make a difference between insight states $|I\rangle$ and pre-consciousness states $|P\rangle$ (see Footnote 8).

5. Quantum Cloning

In reference (Martin, Carminati and Galli Carminati, 2010) we have used a sequence of swappings so that the preconscious qubit $|P\rangle$, closest to consciousness, is in the quantum state of the unconscious qubit $|U\rangle$. Then this preconscious qubit $|P\rangle$ interacts with the consciousness qubit $|C\rangle$.

Another way to process is to clone the information carried by the unconscious qubit $|U\rangle$ on a preconscious qubit $|P\rangle$. But there is a *no-cloning theorem*: *No quantum operation can duplicate perfectly an arbitrary quantum state* (Wootters and Zurek, 1982).[14] If instead of using a sequence of swappings to transfer the quantum information of the unconscious qubit $|U\rangle$ on the preconscious qubit $|P\rangle$, closest to consciousness, we use cloning to transfer this information it will be only approximate, at best optimal (with fidelity $F = 5/6$). This is very interesting because one knows that when a dream becomes conscious the information contained in the dream has been transformed. Moreover in the case of an archetype the information contained in it acquires a special content only when it has been filled with the material of conscious experience (Jung, 1971).

As in quantum optics, it may be possible to use cloning as amplification of the quantum state of unconscious qubit $|U\rangle$. In quantum optics, for a given energy (or frequency), we consider the qubits of the light field in two independent modes, corresponding to two orthogonal polarizations, horizontal and vertical. The light amplification process is based on stimulated emission (Haroche, 2010; Scarani *et al.*, 2005). In well-defined conditions this amplification process can attain the optimal fidelity for a symmetric, universal $N \rightarrow M$ cloning of qubits (cloning N identical qubits on M qubits; optimal fidelity $F_{N\rightarrow M} = (MN + M + N)/M(N + 2)$) (Gisin and Massar, 1997).

[14] Cloning a quantum state $|\Psi\rangle_a$ is duplicating it in a quantum system $|\Psi\rangle_a \otimes |\Psi\rangle_b$ where the quantum state $|\Psi\rangle_b$ is identical to the quantum state $|\Psi\rangle_a$. On the contrary, swapping quantum states $|\Psi\rangle_a$ and $|\Psi\rangle_b$ is exchanging the information between the two quantum states, so that $|\Psi\rangle_a \otimes |\Psi\rangle_b$ becomes $|\Psi\rangle_b \otimes |\Psi\rangle_a$.

In the psyche we will suppose that it is possible (for example by using quantum circuits similar to the one of Figure 5) to clone the unconscious qubit $|U\rangle$ on (M-1) preconscious qubits $|P\rangle$ closest to consciousness with the following unitary operation (Gisin and Massar, 1997; Bruss *et al.*, 1998):[15]

$$|U\rangle \otimes |P\rangle^{\otimes(M-1)} \otimes |M\rangle \rightarrow |\Psi\rangle \qquad (10)$$

where $|M\rangle$ is the quantum state of the ancilla M which mediates the interaction between the quantum systems $|U\rangle$ and $|P\rangle^{\otimes(M-1)}$. In this process the information contained in the initial unconscious qubit $|U\rangle$ is shuffled between the states $|U\rangle$, $|P\rangle^{\otimes(M-1)}$ and (possibly) the ancilla state $|M\rangle$. The state $|\Psi\rangle$ is a quantum entangled state of state $|U\rangle$, (M-1) states $|P\rangle$ and ancilla state $|M\rangle$. If the cloning is universal and symmetric the M reduced density operators corresponding to state $|U\rangle$ and (M-1) states $|P\rangle$ are the same.

Let us consider first the case M=2, i.e., cloning qubit $|U\rangle$ on qubit $|P\rangle$ in a universal, symmetric and optimal way (Buzek and Hillery, 1996). The initial unconscious qubit $|U\rangle$ is given by formula (2) which we can also write:

$$|U\rangle = e^{-i\phi/2}\cos(\theta/2)|0\rangle + e^{i\phi/2}\sin(\theta/2)|1\rangle \qquad (11)$$

Figure 5 shows the optimal cloning circuit in the case of an initial preconscious state $|P\rangle = |P0\rangle = |0\rangle$. For any initial qubit $|P\rangle$ there is a universal and symmetric cloning which leads to the same reduced density operators for U and P:

$$\rho_U^{final} = \rho_P^{final} = F|U\rangle\langle U| + (1-F)|U^{\perp}\rangle\langle U^{\perp}| \qquad (12)$$

where F is the fidelity (independent of the initial state $|U\rangle$, due to universality) and:

$$|U^{\perp}\rangle = e^{-i\phi/2}\cos(\theta/2)|0\rangle - e^{i\phi/2}\sin(\theta/2)|1\rangle \qquad (13)$$

$|U^{\perp}\rangle$ is the state orthogonal to the state $|U\rangle$, corresponding to the vector opposite to $|U\rangle$ on the Bloch's sphere (Figure 2). $|U^{\perp}\rangle$ is also called the *anticlone* state of the input state $|U\rangle$. There is a maximum value of the fidelity, $F_{\max} = 5/6$, which is obtained with an optimal cloning (Buzek and Hillery, 1996)(Figure 5).

Let us now consider the case of cloning (10) for any (M-1) qubits $|P\rangle$, i.e., cloning qubit $|U\rangle$ on (M-1) qubits $|P\rangle$ in a universal, symmetric and optimal way. A universal and symmetric cloning of unconscious qubit $|U\rangle$ leads to the same reduced density operator for U and (M-1) P:

$$\rho_{1\rightarrow M} = F_{1\rightarrow M}|U\rangle\langle U| + (1-F_{1\rightarrow M})|U^{\perp}\rangle\langle U^{\perp}| \qquad (14)$$

where $|U\rangle$ and $|U^{\perp}\rangle$ are respectively given by (11) and (13). $F_{1\rightarrow M}$ is the fidelity, whose maximum value is:

$$F_{1\rightarrow M} = \frac{2M+1}{3M} \qquad (15)$$

which is obtained for a universal, symmetric and optimal cloning (Gisin and Massar, 1997). For large M this maximum value of the fidelity is approximately 2/3. Let us notice that in this approximate process of cloning, unconscious state of U and (M-1) preconscious states of P are no more pure states but became mixed states. Anyway we have amplified approximately the information contained in the unconscious state $|U\rangle$ onto (M-1) preconscious states $|P\rangle$ with a maximum fidelity given by (15). This process of amplification helps the information of the unconscious to reach consciousness. But as we said earlier, in this process of amplification, the information of the unconscious can be transformed (like in a dream that reaches consciousness).

So far we have considered unconscious quantum state $|U\rangle$ and preconscious quantum state $|P\rangle$ as qubits, i.e., two levels quantum states (belonging to Hilbert spaces of dimension 2).

It is possible to generalize unconscious and preconscious quantum states to be d-dimensional quantum systems. In this case we don't call them qubits but "qudits" (Haroche,

[15] The correspondence between formula (10) and Figure **5** is the following: $|U\rangle$ corresponds to $|\Psi\rangle_a$ on Figure **5**, $|P\rangle^{\otimes(M-1)}$ (with $M=2$) corresponds to $|0\rangle_b$, and $|M\rangle$ corresponds to $|0\rangle_m$.

2010; Scarani *et al.,* 2005). Those systems can be represented like an angular momentum $J = (d - 1)/2$ and we can decompose their density operators on a basis of tensorial operators which generalizes the basis of Pauli matrices for greater spaces.

In this case there exists also an optimal symmetric cloning of the unconscious quantum state $|U\rangle$ onto (M-1) preconscious quantum state $|P\rangle$ (Scarani *et al.,* 2005; Keyl and Werner, 1999). The state of each clone is of the form:

$$\rho_{1\to M} = \eta_{1\to M}|U\rangle\langle U| + (1-\eta_{1\to M})\frac{I_d}{d} \qquad (16)$$

where $|U\rangle$ is the input unconscious state, I_d is the identity operator on the d-dimensional Hilbert spaces, and where the shrinking factor $\eta_{1\to M}$ is:

$$\eta_{1\to M} = \frac{M+d}{M(1+d)} \qquad (17)$$

corresponding to an optimal fidelity:

$$F_{1\to M}(d) = \frac{1}{M} + \frac{2(M-1)}{M(1+d)} \qquad (18)$$

As in the case of qubits we obtain an amplification of the information contained in the unconscious state $|U\rangle$ onto (M-1) preconscious states $|P\rangle$. This amplification of the information is approximate, with a maximum fidelity given by (181818).

6. Consciousness

There are several types of consciousness (van Gulick, 2004; Chalmers, 1995; 1996):

1. the awareness of our environment (perceptive consciousness),
2. the awareness of a stimulus (probably the same as perceptive consciousness),
3. the realization of an unconscious or preconscious state (awake states of consciousness),
4. asleep state of consciousness,
5. self-awareness,
6. active consciousness and passive consciousness,
7. awareness of synchronicity phenomena (Jung and Pauli, 1955; Martin, 2009),
8. altered consciousness (visions, voices…) (Geels, 2011).

a. Perceptive consciousness

When we see a (classical) object in our environment it is because several photons which have been either scattered (or emitted) by the object strike our eyes. As Zurek (2007) points out: "Observers access directly only the record of state (or object) S made in the environment, an imprint of the original state of S on the state of a fragment of environment E. There are multiple copies of that original that are disseminated, e.g., by the photon environment. We can find out the state of various systems indirectly, because their correlations with E (which can be quantify using mutual information) allow *E to be a witness to the state of the system.*"

Then Zurek goes on: "Objectivity arises because the same information can be obtained independently by many observers from many fragments of E". It is what Zurek calls "redundancy in E".

Environment E acts not only as *a witness to the state of the system S but also as a transfer of information from S to observers.*

If S is a quantum system "preferred states of S emerge from dynamics, i.e., from interaction between the system S and environment E. States that are immune to monitoring by the environment[16] are predictable, and at least in that sense the most classical." Those states are called pointer-states (Zurek, 2007).

Coming back to objectivity as discussed by Zurek, for a quantum system S, he asks the question:

> "What is the preferred observable capable of leaving multiple records in E: Only states that can be monitored without getting perturbed can survive long enough to deposit multiple copies of their information - theoretic progeny - in the environment."

> "The crux of the matter - the reason why interaction with the environment can impose classicality - is precisely the emergence of the preferred states. Its role and the basic criterion for singling out preferred pointer-states was discovered when the analogy between the role of the

[16] According to Zurek (2007), "states that are immune to monitoring by the environment" are states that remain stable when interacting with the environment.

> environment in decoherence and the role of the apparatus in measurement were understood: What matters is that there are interactions that transfer information and yet leave selected states of the system unaffected. This leads one to einselection - to the environment induced superselection of preferred pointer-states" (Zurek, 1981).

As far as information is concerned, "in quantum setting, information and existence become interdependent. The real state is defined and made objective by what is known about it - by the information. "It from bit" comes to mind (Wheeler, 1990). The main ingredient is the environment. *E* acts as a witness of the quantum state of the "object of interest". It has information - many copies of information - about *S*. Information must reside somewhere (*e.g.,* in the environment)" (Zurek, 2007).

In another article (Zurek, 1998) Zurek asks the question:

> "Why don't we perceive superpositions?" Then he answers: "This question has a straightforward answer. The very physical state of the observer and, thus, his *identity* is a reflection of the information he has acquired. Hence, the acquisition of information is not some abstract, physically insignificant act, but a cause of reshaping of the state of the observer."

As far as consciousness is concerned "coherent superpositions of two conscious states will disappear on the decoherence timescale in the presence of the environment." So it is due to the presence of the material environment that we can have only one thought at a time, although one can think about one subject while our consciousness perceives some object in our environment, or listens to some music.

Figure 6. Superimposed pictures of a young and an old woman.

b. Special feature of consciousness

A metaphor for the principle of superposition of states in quantum physics is made up by the superimposed pictures that we show to a subject's eyes. One example is the famous picture on which we see either a young woman or an old one, but not both simultaneously (Figure 6).[17] Our consciousness sees one of the two pictures, one of the two "pointer-states", which are composed respectively of the young woman and of the old one, but never see both at the same time. This shows the uniqueness of the result of a measurement made by our consciousness at a definite time.

If we consider the picture of the two women on a sheet, or on the screen of a computer, it is not a quantum system, it is a classical one. Therefore it is not a quantum superposition of two states. However, if we place ourselves at the level of picturing, at the level of the representations of our mental states, we could consider that our brain, or our consciousness, is making a quantum superposition of states from this classical picture. In that case our consciousness is really looking at a quantum superposition of states. When we see the picture blurred, i.e., when we don't see either the young woman or the old one, our consciousness is looking at the interference between the two. On the other hand, when our consciousness sees either the young woman or the old one, it sees the "pointer-states". We should stress that, as far as mental states are concerned by this picture, there is no decoherence phenomenon, because the interferences between the two "pointer-states" are still present. If there would have been decoherence these interferences would have disappeared.

This last point is very important because it shows the difference between mental states and physical states (at least physical "pointer-states").

Let us notice that in the same line of thought, as far as mental states are concerned by this picture, there is no collapse of the wave function (or reduction of the wave packet).

c. Awareness of unconscious states

The question is: Does an unconscious state come to consciousness in the same way as a state of the external world? The answer seems to be no.

[17] Anonymous German drawing, 1888. See also reference Hill, 1915.

There are interactions between unconscious quantum states. Those interactions could be either contact interactions, e.g., between qubits as in formulae (4), (6) and (7), or interactions through exchange of a quantum of a psyche field (like two electrons interact electromagnetically through the exchange of a photon).

In any case we have seen that according to those interactions the information of an unconscious quantum state $|U\rangle$ (e.g., a qubit) could be transferred in a unitary way to a preconscious state $|P\rangle$ close to consciousness. If there is amplification of the unconscious quantum information, e.g., from an unconscious qubit $|U\rangle$ to $(M-1)$ preconscious qubits $|P\rangle$ (with $M \geq 3$), due to the *no-cloning theorem*, this amplification is only approximate, but could be optimal.

Once the unconscious information has become a preconscious one (in a complete or approximate way) the interaction with consciousness will acts as a board of censors. It will let or prevent the information, or part of this information, to reach consciousness. Does this "censor" interaction act in a unitary way? We know that for matter the last step of the transition from quantum to classical (the choice of the pointer-state) is a non-unitary transformation. In order to answer this question for unconscious states, in addition to the comment made at the end of the previous section (6.b), let us point out a difference between unconscious states coming to consciousness and the measurement of an observable of a quantum state of matter.

If we consider a two photon entangled state, in which the polarizations of the two photons are quantum correlated, it forms a *non-separable* state. If we measure the polarization of one photon, the other photon polarization will be determinate. However the *non-separable* state, the quantum entangled state, will be destroyed. The measurement will have caused a quantum jump (some sort of collapse) which is a non-unitary transformation.

This is not the case for quantum entangled unconscious states. As an example let consider two twins who buy simultaneously and at a distance two identical neckties without having consulted each other beforehand. When they become conscious of that correlation, contrary to what happens with the photons, it does not destroy their quantum entangled unconscious state. Therefore in this case there is no need to appeal for a quantum jump or a non-unitary transformation. This is general for all unconscious or preconscious states coming to consciousness.

One reason is that the *non-separable* unconscious system made by the two parts of the twins' unconscious which are quantum entangled is much more complex than the *non-separable* system made up of two quantum entangled qubits. As already said, another reason is that when we become conscious of a correlation between two unconscious, there is no such thing as decoherence and/or collapse of a wave function.

Let consider the quantum entangled state $|U,P,C\rangle$, between unconscious, preconscious and conscious states, given by formula (26) of (Martin, Carminati and Galli Carminati, 2010):

$$|U,I,C\rangle = e^{-i\phi/2}\cos(\theta/2)|U0\rangle|I0\rangle|C0\rangle + e^{i\phi/2}\cos(\theta/2)|U1\rangle|I1\rangle|C1\rangle \quad (19)$$

If the state $|C0\rangle$ (e.g., father is dead) comes to consciousness, contrary to what happens in quantum physics, this does not mean that there will be a quantum jump of unconscious state $|U\rangle$ to $|U0\rangle$. $|U\rangle$ will still be given by formula (24) of (Martin, Carminati and Galli Carminati, 2010), perhaps with a slight change of angles θ_U and φ_U due to the awareness of state $|C0\rangle$.

Therefore there is no need of quantum jump in the awareness of unconscious states. There is no collapse of the wave function either, nor decoherence phenomenon. Unitary transformations are presumably sufficient.

d. Pointer-states of unconscious quantum systems

Now what about the pointer-states of quantum states in the unconscious domain? As we have seen above, according to Zurek, the pointer-states of a quantum system are those states that are immune to monitoring by the environment and which deposit the same

information in many fragments of the environment (redundancy).

If we consider the external environment, the pointer-states of perceptive consciousness will be also pointer-states of some unconscious states. But if we consider only the unconscious domain, the problem will be the interaction of an unconscious state with the whole unconscious, including the Collective Unconscious and archetypes.

The fact that there is a decoherence phenomenon for physical quantum system interacting with the environment is due to the randomization of this environment (i.e., the chaotic motion of air molecules or the non-coherence of the light coming from the sun or from an artificial source). We will assume that there is no such randomization in the unconscious. Therefore the unconscious will avoid decoherence.

7. Archetypes

We will consider now archetypes and their interactions with other parts of the unconscious, e.g., individual unconscious and the Collective Unconscious (e.g., collective memory states of the human species).

Concerning archetypes, C. G. Jung wrote: "I always find again this misunderstanding which presents the archetype as having a specified content; in other words one makes it a kind of unconscious "representation", if I may put it that way. Therefore it is necessary to make clear that archetypes do not have a specified content; they are only determined in their *form* and yet to a very limited extent. A primary image has a specified content only when it becomes conscious and is consequently filled with the material of conscious experience" (Jung, 1971: p.576).

Further on Jung wrote: "The archetype in itself is empty; it is a pure formal element, nothing more than a *facultas praeformandi* (a possibility of pre-formation), a form of representation given *a priori*" (Jung, 1971: p.576).

Therefore the archetypal representations which appear in fantasies, dreams, delusions and illusions of individuals are different each time they appear to consciousness. "*We never make exactly the same dream*".

Archetypes are certainly special quantum states. We will call Archetypes (with a big A) those Archetypes that are defined by Jung as "empty of form", i.e. empty of any representation. Those Archetypes are quantum systems which simply contain quantum information. They could be quanta of the Universal Unconscious Quantum Field.

The interaction of those Archetypes with an individual unconscious (especially with memory states) and also with the Collective Unconscious (especially the collective memory states of the human species) will make appear archetypes (with a small a) which will be representations of the Archetypes. Can we consider those archetypes as "pointer-states" of the unconscious? In a sense yes we can. But they are a little more complex than "pointer-states" of a physical quantum system.

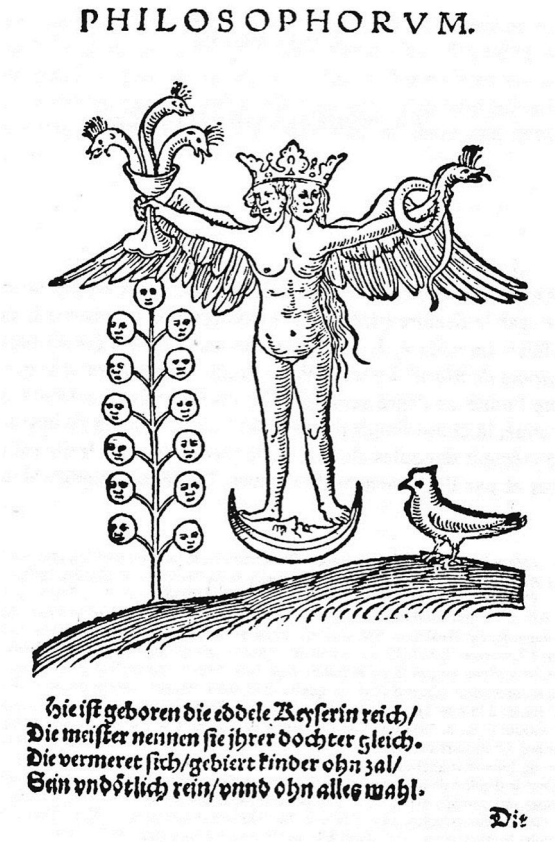

Figure 7. Rebis (Jacob, 1550).

If we consider the spin of the electron, the value of this spin is 1/2. If the physical observable is just the value of this spin we know that this value is 1/2, but we do not have any information about the direction of this spin. Therefore at this level of knowledge there

is no "pointer-states" of the spin-system (except the value 1/2). To introduce "pointer-states" of this spin-system we need to put the electron in a magnetic field. This will introduce two "pointer-states" along the direction of the magnetic field: up and down. At this point there is no measurement of the spin of the electron, just the determination of "pointer-states". If we do a measurement, in that case there will be a choice of one of the two "pointer-states": up or down. It is very important to note that to define pointer-states of a quantum physical system there is no need to do a measurement but only to put the quantum system in some definite environment.

According to Jung, an archetype (a representation or a symbol of an Archetype) unifies the opposites. A symbol is a pictorial combination of opposites, irreconcilable for human consciousness (like the wave and the corpuscular aspects of matter in quantum physics). Therefore an archetypal symbol is a formulation of a living paradox. In this way all archetypes are conjunctions of opposites.

For example we could consider that Figure 6 is an archetype (a representation of an Archetype). The Archetype would be Time. Now the equivalent of the magnetic field for the spin of the electron would be, in that case, the concept of "Woman", which is a real concept (as Jung said: "some material of conscious experience"). The interaction of Time with the concept of "Woman" will create two opposites (two "pointer-states", like up and down for a spin 1/2): the young woman and the old woman. Figure 6 shows those two "pointer-states" on the same picture, a fact which is different from what happens in quantum physics, because if we measure the spin of the electron we will get up or down, but not both at the same time.

The same process happens in alchemy for the Rebis (Figure 7) which is a representation of the androgynous *Mercurius*, a symbol of the androgyne or of the hermaphrodite. In this case the Archetype is the concept of Sex. The "material of conscious experience" which will play the role of the magnetic field for the electron spin will be the concept of "Human Being". The interaction of Sex with the concept of "Human Being" will create two opposites, two "pointer-states": male and female. Those two "pointer-states" appear together in the Rebis. The same archetype can appear as different figures, depending on the cultural context. It can be, as we just have seen, the androgynous *Mercurius* in alchemy, or the Hindu God Shiva with the two sexes (bas-relief in Elephanta Caves, Figure 8). It can also be those Maya statues, pieces of pottery, with two heads: one male and one female.

We can conclude that, as far as archetypes are concerned, there is a major difference between a measurement in quantum physics and the representation of an Archetype. A measurement in quantum physics gives only one answer (only one pointer-state is chosen). It is what we call the transition from quantum to classical. On the contrary in the representation of an Archetype all "pointer-states" coexist. There is no phenomenon such as a transition from quantum to classical. Nothing becomes classical. Everything remains quantum!

Figure 8. Shiva in Elephanta Caves [Martins].

Let us notice that unconscious states are internal states and that, to some extent, consciousness can be regarded as the "experimental" detector of those internal states. The fact that consciousness is also an internal state, i.e. that we are both the subject who observes and the "object" which is observed, could explain this difference of status between "external" quantum states and "internal" quantum states. Thus, this could explain that, contrary to physical states, archetypes (representations of Archetypes) keep their quantum double aspect when they come to consciousness. In a sense archetypes remain in an *unfragmented* form, whereas physical states appear to us in a *fragmented* form.

7.1 Mathematical Archetypes

Now let consider mathematical entities and mathematical theorems. Some people think that they are only creations of the human brain others thinking that they predate their discovery by mathematicians (Changeux and Connes, 1989). For the second ones they are some sort of Archetypes. Mathematicians give them a representation which is immune to monitoring by the environment and which deposit the same information in many fragments of the environment (redundancy). In that meaning those representations are "pointer-states". They satisfy the "objectivity" criterion since they are shared by all mathematicians over the world. They acquire *a relatively objective existence* that gives them "a smell of classicality".

What is true for mathematical entities and mathematical theorems is also true for the (physical) laws of Nature. Then one can ask the question: how what appears to be true for mathematical archetypes, i.e. *relatively objective existence*, is also true for psychological Archetypes? The answer is yes. We have seen that it is possible to give a *relatively objective existence* to psychological Archetypes through some universal representations. But, contrarily to mathematical or physical archetypes, first they depend on the cultural environment; secondly, they do not get any "smell of classicality", they remain quantum.

8.Conclusions

In quantum physics, the existence of a quantum system becomes apparent in a Hilbert space. Space-time is only one representation among many others. Moreover it is not necessarily the most useful representation. Many quantum processes, e.g. quantum entanglement, are a-spatial and a-temporal. "Quantum entanglement supports the idea that the world is deeper than the visible, and reveals a domain of existence, which cannot be described with the notions of space and time. In the nonlocal quantum realm there is dependence without time, things are going on but the time doesn't seem to pass here" (Suarez, 2003).

The space-time representation of quantum processes is based on the notion of wave function and on quantum field theory. In this context, by analogy with quantum field theory of matter, we (Baaquie and Martin, 2005) have postulated the existence of an underlying universal mental (unconscious and consciousness) quantum field. It appears that it is a quantum interpretation, in terms of quantum fields, of the layered model of the Collective Unconscious that Jung gave in 1925.

In reference (Galli Carminati and Martin, 2008) we put aside the space-time representation of quantum processes. Thus we studied quantum entanglement between various unconscious, and between unconscious, pre-consciousness and consciousness, through its relational side rather than through its spatiotemporal side. This led us (Martin, Carminati and Galli Carminati, 2010) to quantum information. In our analogy with the theory of NMR, we still had to use some space-time representation through the influence of mental quantum fields.

In this paper we reminded our views on the transfer of information between mental quantum bits (qubits), putting the emphasis on the role of mental quantum fields. To some extent we have combined the space-time representation with the relational one.

In quantum information, there is a *no-cloning theorem* (Wootters and Zurek, 1982). Therefore if we apply it to the amplification of unconscious information, in order for it to reach consciousness, we saw that this amplification will only be approximate, at most optimal. The information of the unconscious will be transformed (like in a dream that reaches consciousness).

Then we dealt with consciousness. We saw that there is a special feature of consciousness which makes the difference with an experimental physics detector. In the latter there is a definite choice of a "pointer-state" which cannot be changed as time goes on. In other words the choice of the "pointer-state" is *irreversible*.[18] As far as consciousness of

[18] "In fact, for measurement to happen it is not necessary at all that a human observer (conscious or not) is watching the apparatuses. However the very definition of measurement makes relation to human consciousness: An event is "measured", i.e., *irreversibly* registered, only if it is possible for a human observer to become aware of it. … One could assume that amplification in a photomultiplier becomes *irreversible* in principle at a certain level, if beyond this level an operation exceeding the human capabilities would be required to restore the photon's quantum state. When such a level is reached the detector clicks. Such a view combines the subjective and the objective interpretation of measurement: on the one hand no human observer has to be actually present in order that a registration takes place, … ; on the other hand one defines the

mental states is concerned, although at a definite moment there is a definite choice of a "pointer-state", we have shown that there is no such thing as *irreversibility*.[19] In Figure 6 our consciousness can move from one "pointer-state" to the other, and even see the superposition and the interferences between the two. In the awareness of mental states, and especially unconscious states, there are no such processes like collapse of the wave function or decoherence.

There are various views about consciousness. One, which is assumed by most neuroscientists, is the *materialist* view (Seth *et al.,* 2006). This view postulates that consciousness is an emergent property of the brain reducible to its neural complexity. Then, there is the view followed in this paper: consciousness is assumed to be an *immaterial universal quantum field* (Baaquie and Martin, 2005; Eccles, 1994), for which any individual consciousness is a particular excitation of this underlying universal mental quantum field. In this view, consciousness is not reducible to the neural complexity of the brain, but is correlated to it (probably via quantum entanglement). However, there is a third view, which takes its roots in the fact that quantum entanglement is "controlled" from *outside space-time*.[20] This view assumes that consciousness is an entity which acts from *outside space-time*: "It is well known that quantum physics supports *experimental metaphysics*: Nothing speaks against considering mind and consciousness quantum-mechanical states of the brain. Actually, *self-organization* is another way of saying that random neural dynamics is controlled from outside space-time by unobservable principles like free will[21] and consciousness: *Self-organization of the brain is synonymous to organization by the Self*" (Suarez, 2008).

There is still a long way, and a lot of work to do, before we really understand what is the essence of consciousness.

This article finishes with some thoughts about Archetypes, a concept introduced by C. G. Jung (1971: p.576). We tried to see if it could be a quantum concept. This led us to two different notions: Archetypes (with a big A) which are quantum systems empty of any representation, and archetypes (with a small a) which will be representations of the Archetypes. Even if they are representations of the Archetypes, archetypes remain quantum; they don't become "*classical*". This point of view seems quite plausible.

'collapse' or 'reduction' with relation to the capabilities of the human observer" (Suarez, 2008; d'Espagnat, 2006).

[19] Let us point out that this is not true for perceptive consciousness of the external world, and also for our choices and actions. In those cases there is *irreversibility*.

[20] "In the quantum world, correlations have their own causes, non-reducible to those of events, and they are insensitive to space and time" (Gisin *et al.,* 2002).

[21] According to Anton Zeilinger (2006), there exist *two freedoms*: "first the freedom of the experimenter in choosing the measuring equipment - that depends on my freedom of will; and then the freedom of nature in giving me the answer it pleases. The one freedom conditions the other, so to speak. This is a very fine property. It's too bad the philosophers don't spend more time thinking about it".

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