Men Who Made a New Science **Invited Article**

Thinking Outside the Box

The Essence and Implications of Quantum Entanglement and the Story of Spin-mediated Consciousness Theory

Huping Hu and Maoxin Wu

Abstract

Many experiments have shown that quantum entanglement is physically real. In this article, we will discuss its ontological origin/nature, implications and potential applications by thinking outside the standard interpretations of quantum mechanics. We argue that quantum entanglement originates from the primordial spin processes in non-spatial and non-temporal pre-spacetime, implies genuine interconnectedness and inseparableness of once interacting quantum entities, play vital roles in biology and consciousness and, once better understood and harnessed, has far-reaching consequences and applications in many fields such as medicine and neuroscience. Then, we will recall our journey into the field of consciousness studies and the inception and development of the spin-mediated consciousness theory.

Key Words: Spin, entanglement, interconnectedness, inseparableness, consciousness, quantum brain theory

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When in the course of scientific endeavor, it becomes apparent that deeper truth exist, a decent respect to Nature requires that such truths be explored. We hold these truths to be scientifically approachable, that all forms of existence are interconnected, that they possess certain fundamental and unalienable properties. That to describe this interconnectedness and these properties, successive theories shall be constructed by mankind, deriving their explanatory and predictive powers from the approximations of laws of Nature. That whenever any theory becomes inadequate of these ends, it is the duties of mankind to modify it or to abolish it, and to establish new ones, laying the foundation on such principles and organizing the structures in such forms, as to mankind shall seem most likely to reflect their understanding and knowledge of Nature.

In memory of Thomas Jefferson

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Introduction

Quantum entanglement is ubiquitous, appears everywhere in the microscopic world (See, e.g., Durt, 2004; Brooks, 2005) and under some circumstances manifests itself macroscopically (Arnesen, *et al*, 2001; Ghost *et al*, 2003 & Julsgaard *et al*, 2001). Indeed, it is currently the most intensely studied subject in physics. Further, speculations abound as to its nature and implications (See, e.g., Clarke, 2004, Josephson, 1991 & Radin, 2004). There are many general and technical papers written on the subject. So cutting to the chase, we shall immediately outline our propositions on the subject and then discuss each in some detail with references to existing literature whenever possible. Readers are advised that our propositions are outside the mainstream physics. Later in this article, we shall recall our journey into the field of consciousness studies and the inception and development of the spin-mediated consciousness theory.

The following are our propositions about the ontological origin/nature, implications and potential applications of quantum entanglement:

1. It originates from the primordial spin processes in non-spatial and non-temporal pre-spacetime. It is the quantum "glue" holding once interacting quantum entities together in pre-spacetime, implies genuine interconnectedness and inseparableness of the said quantum entities and can be directly sensed and utilized by the entangled quantum entities.
2. Thus, it affects chemical/biochemical reactions, other physical processes and micro- and macroscopic properties of all forms of matters as already shown by some authors in the latter case. It plays vital roles in many biological processes and consciousness. It is the genuine cause of many so called anomalous effects (if they do exist) in parapsychology, alternative medicine and other fields as some authors have already suspected in some cases
3. Further, it can be harnessed, tamed and developed into revolutionary technologies to serve the mankind in many areas such as health, medicine and even recreation besides the already emerging fields of quantum computation and communications.

Origin and Nature of Quantum Entanglement

Popular opinion has it that Erwin Shrödinger coined the word "entanglement" and first used it in 1935 in his article published in the Proceedings of Cambridge Philosophical Society (Shrödinger, 1935). Mathematically, Shrödinger showed that entanglement arises from the interactions of two particles through the evolution of Shrödinger equation and called this phenomenon the characteristic trait of quantum theory (*id.*). Einstein called quantum entanglement "spooky action at a distance" in the famous EPR debate (See, e.g., Einstein *et al*, 1935).

Ontologically, we argue that quantum entanglement arises from the primordial self-referential spin processes which we had argued previously are the driving force behind quantum mechanics, spacetime dynamics and consciousness (Hu & Wu, 2003; 2004a). Pictorially, two interacting quantum entities such as two electrons get entangled with each other through the said spin processes by exchanging one or more entangling photons with entangling occurring in pre-spacetime. Such ontological interpretation is supported by the existing literature as discussed below.

First, Hestenes showed that in the geometric picture for the Dirac electron the zitterbewegung associated with the spin is responsible for all known quantum effects of said electron and the imagery number ***i*** in the Dirac equation is said to be due to electronic spin (See, e.g., Hestines, 1983).

Second, in Bohmian mechanics, the "quantum potential" is responsible for quantum effects (Bohm and Hiley, 1993). Salesi and Recami (1998) have recently shown that said potential is a pure consequence of "internal motion" associated with spin evidencing that the quantum behavior be a direct consequence of the fundamental existence of spin. Esposito (1999) has expanded this result by showing that "internal motion" is due to the spin of the particle, whatever its value. Bogan (2002) has further expanded these results by deriving a spin-dependent gauge transformation between the Hamilton-Jacobi equation of classical mechanics and the time-dependent Shrödinger equation of quantum mechanics which is a function of the quantum potential of Bohmian mechanics.

Third, spin is a unique quantum concept often being said to have no classical counterpart (See Tomonaga, 1997). Unlike mass and charge that enter a dynamic equation as arbitrary parameters, spin reveals itself through the structure of the relativistic quantum equation for fermions that combines quantum mechanics with special relativity (Dirac, 1928). Indeed, many models of elementary particles and even space-time itself are built with spinors (Budinich, 2001; Penrose, 1960 & 1967). Pauli (1927) and Dirac (1928) were the first to use spinors to describe the electron. Also, Kiehn (1999) showed that the absolute square of the wave function could be interpreted as vorticity distribution of a viscous compressible fluid that also indicates that spin is the process driving quantum mechanics.

Therefore, in view of the foregoing it could be said that the driving force behind the evolution of Shrödinger equation is quantum spin and, since quantum entanglement arises from the evolution of Shrödinger equation the said spin is the genuine cause of quantum entanglement.

What do we mean by pre-spacetime? Pre-spacetime in this article means a non-spatial and non-temporal domain but it is not associated with an extra-dimension in the usual sense since there is no distance or time in such domain (See, Hu & Wu, 2002). We have argued before that in a dualistic approach mind resides in this domain and unpaired nuclear and/or electronic spins are its mind-pixels (*id.*). So pre-spacetime is a holistic domain located outside spacetime but connected through quantum thread/channel to everywhere in spacetime enabling quantum entanglement or Einstein's "spooky action at a distance." Aerts (2004), Clarke (2004) and others have also expressed the non-space view of quantum nonlocality.

Such a non-spatial and non-temporal pre-spacetime is a "world" beyond Einstein's relativistic world but does not contradict with the latter since the latter deals with classical physical events occurring within spacetime. In contrast, quantum entanglement occurs within non-spatial and non-temporal domain. Therefore, instantaneous signaling through quantum entanglement in pre-spacetime is possible if the entangled quantum entities can directly sense and/or utilize the entanglement.

So what is then the essence of quantum entanglement? We propose that quantum entanglement is not merely the correlations of certain physical parameters in the process of

measurement but genuine interconnectedness and inseparableness of once interacting quantum entities. It is the quantum "glue" holding once interacting quantum entities together in pre-spacetime and can be directly sensed and utilized by the entangled quantum entities as further discussed below. It can be diluted through entanglement with the environment, *i.e.*, decoherence.

Implications of Quantum Entanglement

It is often said that instantaneous signaling through quantum entanglement is impossible because of Eberhard's theorem that basically says that since local measurements always produce random results no information can be sent through quantum entanglement alone (Eberhard, 1978). However, there are two ways to circumvent this impossibility. But both require one to go beyond the standard interpretations of quantum mechanics. The first is to assume that the statistical outcomes of quantum measurement can be affected or modified by consciousness. Quite a few authors have expressed this view (Josephson, 1991; Stapp, 1982 & Walker, 1974) especially when discussing phenomena in parapsychology such as telepathy. The second is to assume that each quantum entity can directly sense and utilize quantum entanglement as already mentioned before. This latter view is the view we subscribe to.

The implication of the second view is far-reaching. It means that quantum entanglement can affects chemical and biochemical reactions and other physical processes. Thus, it plays vital roles in many biological processes and consciousness and is the genuine cause of many anomalous effects, if they do exist, in parapsychology, alternative medicine and other fields as some authors have already suspected in some case. It can affect the micro- and macroscopic properties of all forms of matters such solid and liquid.

For example, the results reported by Rey (2003) that heavy water and highly diluted solutions of sodium chloride and lithium chloride behaved differently in the thermo-luminescence tests can be explained as the consequence of water molecules forming different hydrogen bonds due to the entanglement of water molecule with sodium chloride or lithium chloride ions being diluted out of existence and its subsequent effect on hydrogen bond formation during freezing. Indeed, in light of the recent results on observable macroscopic entanglement effects (Arnesen, *et al*, 2001; Ghost *et al*, 2003), the explanation offered herein is most likely true.

For a second example, the so called "memory of water" effect (Davenas, *et al*, 1988), which is largely discredited by the mainstream scientists because of non-reproducibility, can be explained as the result of entanglement of the substances being diluted with water and then the subsequent entanglement of water with the quantum entities in the biochemical processes responsible for producing certain visible or detectable result. Of course, quantum entanglement cannot directly serve as a reagent in a chemical reaction nor can it be recorded or transferred through any classical means such as a digital device within a computer or the telephone wire. So any claim of recordable or telephone -wire-transferable "chemical signal" cannot be attributed to quantum entanglement.

Similarly, the therapeutic effect of a homeopathic remedy, if it truly exists beyond and above the placebo effect, can be explained as the entanglement of the substances being diluted out of existence through vigorous shaking/stirring with the diluting solvent and then the subsequent entanglement of the solvent with the quantum entities involved in the diseased biological and/or physiological processes and the effect of such entanglement on the latter processes. Indeed, there are reports in the existing literature exploring the use of generalized entanglement to explain the therapeutic ingredient in a homeopathic remedy (See, e.g., Milgrom, 2002; Wallach, 2000 & Weingärtner, 2003).

Further, many other unconventional healing effects reported in alternative medicine, if they are genuine, can be explained as the results of quantum entanglement between the quantum entities involved in the diseased processes and the quantum entities in the healing sources, such as a healthy biological entity, and the effect of the former on the latter processes.

For yet another example, all the results from Princeton Engineering Anomalies Research program over the last 26 years (Jahn & Dunne, 2005) can also be straightforwardly explained as the entanglement of the quantum entities controlled by human mind with the quantum entities responsible for the physical processes capable of producing modified random results. By the same token, many if not all anomalous effects reported parapsychology such as telepathy and those results reported by Grinberg- Zylberbaum (1987) and the repeaters (For a summary, see, Wackermann, 2005) can be simply explained as the results of quantum entanglement between the quantum entities capable of invoking action potentials in one person and those in a second person and the effect of one on the other through quantum entanglement. Grinberg-Zylberbaum himself speculated that his results had something to do with quantum entanglement (1994).

Potential Applications of Quantum Entanglement

Recently, quantum computation and communication through teleportation have been achieved in the laboratory but they are implemented in controlled environment to prevent decoherence through entanglement of the system of interests with the said environment. Indeed, it is also often said that the reason why we don't experience quantum entanglement in the macroscopic world is because of rapid decoherence within the macroscopic system. However, this view may rapidly change (See, *e.g.*, Brooks, 2005). We are convinced that quantum entanglement can be harnessed, tamed and developed into revolutionary technologies to serve the mankind in many areas such as health, medicine and even recreation besides the emerging fields of quantum computation and communications.

For example, once harnessed, quantum entanglement technologies can be used to deliver the therapeutic effects of many drugs to a target biological system such as a human body without ever physically administrating the said drugs to the said system. Such technology would dramatically reduce waste and increase productivity because the same drugs can be repeatedly used to deliver their therapeutic effects to the mass. By the same token, many substances of nutritional and even recreational values can be repeatedly administrated to the human body through the said technologies. For a second example, the harnessed quantum entanglement technologies can also be used to entangle two or more

human minds for legitimate purposes. Further, the said technologies can be used for instantaneous communications with humans sent to the outer space.

Are we delusional? Only time will tell. But we are convinced that the wonders of quantum entanglement technologies will be realized very soon and a new paradigm of science will be born in the near future.

The Story of Spin-Mediated Consciousness Theory

Like many others before us, our motive for studying consciousness is self-enlightenment. By that we mean that we would like to find out the answers to the big questions: who are we, where did we come from, where are we going to and how can we achieve immortality? Obviously, to find answers to these big questions, we need first find out what is consciousness and how does the brain produce consciousness?

The inception of the spin-mediated consciousness theory was cultivated by several factors. Author Hu has had a long involvement with the studies and experimental applications of both electronic and nuclear spins. He used to study theoretical physics on his own during his undergraduate days in China during 1979-1983 while majoring chemistry (not by choice). He took the graduate entrance examination in theoretical physics offered by the Department of Physics, Lanzhou University, China in the spring of 1983 and got accepted into its graduate program. Upon arrival for interview with his advisor Professor Yishi Duan, Duan told him that biophysics, an interdisciplinary field, was a much more exciting place to be then theoretical physics, especially with Hu's background in chemistry. Hu listened and got transferred to the Biophysics Division in the Department of Biology with Professor Rongliang Zheng as his supervisor. Hu studied biophysics under Zheng during 1983-1986, was exposed to a variety of biophysical instrumentations and did his thesis research on the biological effects of free radicals by applying electron spin resonance ("ESR") spectroscopy. There he also learned that oxygen has two unpaired electrons and thus, is paramagnetic and is involved in many free radical mediated biological processes. In the meantime, Hu continued his study of theoretical physics on his own and published a few papers in the areas of Dirac magnetic monopoles and non-Abelian gauge fields. Hu also tried to crack the DNA codes, that is, to find the internal meanings of the triplet codes, wrote an unpublished manuscript about it and given seminars on it. He also published a short article on the concept of "individual entropy" and its conservation law in a Chinese magazine called "Potential Science."

Upon graduation in 1986, Hu applied to the Department of Physiology and Biophysics, University of Illinois at Champaign-Urbana for his Ph.D. study in biophysics and got accepted there with Professor Harold M. Swartz as his supervisor. Indeed, he owes much to Zheng and Swartz for the opportunity. His Ph.D. study, besides mandatory and selective courses in biophysics and related field such as NMR and MRI, was focused on the development of nitroxides, which contain stable unpaired electrons, for simultaneous measurement of intra- and extracellular oxygen concentration using ESR spectroscopy. Hu spent five years from 1987 to 1991 at University of Illinois before he got his Ph.D. in biophysics. Hu married the second author Wu in 1986 in China and worked with her in Swartz's laboratory for a few years while she was pursuing her Master's degrees. Later, Wu went on to obtain her Ph.D., finished her medical training and became a medical doctor.

It was during the period of his Ph.D. studies Hu read some articles and papers in the journal Nature about the mechanism of general anesthesia and came up with the ideas of active oxygen transportations in cells which he discussed with Swartz and perturbation of oxygen pathways being involved in general anesthesia which he only discussed with Wu thinking the latter idea was too premature.

After obtaining his Ph.D., Hu then left science and went into business for a few years from 1991 to 1993. After he failed at business, he applied and went to New York Law School to study for his law degree from 1994 through 1997. While he was attending law school in the evenings, he worked for the Bronx District Attorneys' Office for a while and then for a law firm located in Manhattan. Upon graduation from law school and admission to the New York Bar in the spring of 1999, Hu went to Wall Street and worked at a few Wall Street firms as a proprietary trader while practiced law on the side until 2003. After Wall Street cooled down, Hu in 2004 set up his own law practice in Flushing, New York and is currently a full-time practicing attorney.

In late 2000, Hu decided to search the Internet and see whether progress had been made in field of general anesthesia when he got bored at trading stocks during the day. He ran across a 1994 News Week article predicting that the mystery of general anesthesia would be solved within five years. It was late 2000 and clearly that prediction utterly failed. It was then Hu decided to further research his earlier idea of oxygen pathway perturbation by general anesthetics and decided to write a paper on it after some ten years had pasted since the idea first came to him. After the paper was written with Wu, Wu suggested to try a journal called Medical Hypotheses that she had heard would publish novel ideas in medicine and related areas. Hu tried and the paper was accepted and publishing in 2001 (Hu & Wu, 2001). At about the same time, Hu ran across a physics e-print server called xxx.lanl.gov and was able to load the paper on January 24, 2001 to that server by using Wu's academic affiliation with Mount Sinai School of Medicine.

Their anesthetic paper was entitled "Mechanism of anesthetic action; oxygen pathway perturbation hypothesis" which basically says general anesthetics produce unconsciousness by perturbing oxygen pathways in neural membranes and proteins (Hu & Wu, 2001). This view is not at all accepted by the scientific community at large. Indeed, there are no commonly accepted theory on how general anesthetics work, despite they have been in use for more than 150 years.

After the anesthetic paper was published, Hu got very interested in solving the mystery of consciousness and spent all his waking moments besides trading stocks thinking about the problem. One late evening while brushing his teath and getting ready to go to bed, Hu suddenly hit the idea that the unpaired nuclear spin and/or electron spins inside the high-voltage neural membranes could be the key to the mystery of consciousness and immedately told Wu about it and she agreed that it is a great candidate. Although Hu knew the importance of the concept of quantum spin in physics for a long time and even contemplated its roles in biology during his graduate school days, it was that night his previous vague ideas get focued and crystalized. Thus, the spin-mediated conscousness theory was born. It took the authors almost a year to put a preliminary paper together and deposit the same on August 11, 2002 into the physics archive xxx.lanl.gov (Hu & Wu, 2002).

The initial reception to the theory by physicists through private e-mails was very positive and encouraging, the same paper was also provisionally accepted for print publication in November 2002 by a major consciousnes journal but was eventually rejected in Janruary 2004 after two revisions and more than a year had passed. A more developed version of the theory was presented in March 2003 at Quantum Mind 2003 and a further developed version was published in Medical Hypotheses in mid 2004. Although published reviews, criticisms or comments on this theory are negligible to non-existent, it is well received at conferences and in private communications by some physicists and the like. Two more papers on the same subject were also published in this electronic journal, NeuroQuantology (Hu & Wu, 2004a; 2004c).

Briefly, the spin-mediated consciousness theory is a theory that says quantum spin is the seat of consciousness and the linchpin between mind and the brain, that is, spin is the mind-pixel (Hu & Wu, 2002, 2004a-d). According to this theory, consciousness is intrinsically connected to the spin process and emerges from the self-referential collapses of spin states and the unity of mind is achieved by entanglement of these mind-pixels (*id.*). It is a tentative hypothesis as are all current hypotheses about consciousness.

The starting point is the fact that spin is basic quantum bit ("qubit") for encoding information and, on the other hand, neural membranes and proteins are saturated with nuclear spin carrying nuclei and form the matrice of brain electrical activities. Indeed, as discussed above, spin is embedded in the microscopic structure of spacetime as reflected by Dirac equation and is likely more fundamental than spacetime itself as implicated by Roger Penrose's work. In the Hestenes picture the zitterbewegung associated with spin was shown to be responsible for the quantum effects of the fermion. Further, in the Bohm picture the internal motion associated with spin has been shown to be responsible for the quantum potential which, in turn, is responsible for quantum effects. Thus, if one adopts the minority quantum mind view, nuclear spins and possibly unpaired electron spins become natural candidates for mind-pixels (Hu & Wu, 2002; 2003; 2004a-d).

Applying these ideas to the particular structures and dynamics of the brain, the authors theorize that human brain works as follows: Through action potential modulated nuclear spin interactions and paramagnetic O2/NO driven activations, the nuclear spins inside neural membranes and proteins form various entangled quantum states some of which survive decoherence through quantum Zeno effects or in decoherence-free subspaces and then collapse contextually via irreversible and non-computable means producing consciousness and, in turn, the collective spin dynamics associated with said collapses have effects through spin chemistry on classical neural activities thus influencing the neural networks of the brain (Hu & Wu, 2002; 2003; 2004a-d). As with other quantum mind theories, decoherence is a major concern as pointed out by Tegmark but may not be insurmountable (See, e.g., Hameroff). We believe that the solution will be found through the studies of quantum entanglement.

Existing literature supports the possibility of a spin-mediated consciousness. For example, it was shown that proton nuclear spins in nematic liquid crystal can achieve long-lived intra-molecular quantum coherence with entanglement in room temperature for information storage (Khitrin *et al*, 2002). Long-ranged (>10 microns) intermolecular multiple-quantum coherence in NMR spectroscopy was discovered about a decade ago

(Warren, et al 1993). Long-lived (>.05 milliseconds) entanglement of two macroscopic spin ensembles in room temperature has been achieved recently (Julsgaard, *et al.* 2001). Further, NMR quantum computation in room temperature is reality (Gershenfeld & Chuang, 1997).

Our theory predicts among other things that (1) replacement of hydrogen with deuterium will affect consciousness; (2) interference with the dynamics of neural nuclear spin ensemble will affect consciousness; (3) perturbation of neural membrane and protein structures and dynamics will affect consciousness; and (4) perturbation/blockage of oxygen pathways in the neural membranes and proteins will also affect or even block consciousness. Therefore, the effect of transcranial magnetic stimulations on awareness and consciousness functions (See Chicurei 2002) can be explained as the stimulations interfering with neural nuclear spin dynamics. General anesthetics causing unconsciousness can be explained as the said anesthetics perturbing O_2 pathways and neural membrane structures and dynamics (See also Hu & Wu 2002). Further, temporary hypoxia causing unconsciousness may be explained as deprivation of O_2 activation functions.

More recently, we have also considered the possible roles of neural electron networks in memory and consciousness (Hu & Wu, 2004d). Besides free O_2 and NO, the main sources of unpaired electron spins in neural membranes and proteins are transition metal ions and O_2 and NO bound/absorbed to large molecules, free radicals produced through biochemical reactions and excited molecular triplet states induced by fluctuating internal magnetic fields. We have shown that unpaired electron spin networks inside neural membranes and proteins are also modulated by action potentials through exchange and dipolar coupling tensors and spin-orbital coupling and g-factor tensors and perturbed by microscopically strong and fluctuating internal magnetic fields produced largely by diffusing O_2. Thus, we have argued that these spin networks could also be involved in brain functions since said modulation inputs information carried by the neural spike trains into them, said perturbation activates various dynamics within them and the combination of the two likely produce stochastic resonance thus synchronizing said dynamics to the neural firings. Although quantum coherence is desirable, it is not required for these spin networks to serve as the microscopic components for the classical neural networks.

On the quantum aspect, we speculate that human brain works as follows with unpaired electron spins being the mind-pixels: Through action potential modulated electron spin interactions and fluctuating internal magnetic field driven activations, the neural electron spin networks inside neural membranes and proteins form various entangled quantum states some of which survive decoherence through quantum Zeno effects or in decoherence-free subspaces and then collapse contextually via irreversible and non-computable means producing consciousness and, in turn, the collective spin dynamics associated with said collapses have effects through spin chemistry on classical neural activities thus influencing the neural networks of the brain (Hu & Wu, 2004d). Thus, according to this alternative model, the unpaired electron spin networks are the "mind-screen," the neural membranes and proteins are the mind-screen and memory matrices, and diffusing O_2 and NO are pixel-activating agents. Together, they form the neural substrates of consciousness.

Finally, the principle of science dictates that a scientific theory/hypothesis should only achieve legitimacy if it is experimentally verified. Thus, since the summer of 2004 to the present, we have mainly focused our efforts on the quantification of our theory and the

designs and implementations of computer simulations and experiments for the verifications of the same. Important results shall be reported as soon as feasible.

About the Authors

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