

Research Essay

Solving the “Hard Problem”: Consciousness is an Electronic Phenomenon

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Abstract

This paper is a reply to a paper “Solving the ‘Hard Problem’: Consciousness is an Intrinsic Property of Magnetic Fields”. It is argued that this paper is essentially correct because it specifically nominates magnetite crystals (Biogenic Magnetic Nanoparticles BMNPs) as the source of magnetic phenomena in the brain and specifically founds this theory on Maxwell’s electromagnetic equations. However the paper fails to arrive at the logical conclusion that consciousness is generated by electronics, that the brain is an electronic device, and that the brains of all living creatures are connected electronic devices. In the paper under reply, the description of electromagnetic processes in the brain (in particular the interaction of magnetic and electric flux) comes across as vague and inadequate. In addition the paper makes certain claims to have solved some of the ‘big questions’ in life such as “mind-body” dualism and solipsism which appear to be logically and philosophically invalid, and Schrödinger’s famous question “What is Life?” and Gödel’s theorem would need to be addressed in any paper that purports to solve the “hard problem”.

Keywords: Consciousness, electronics, magnetic flux, electric flux, ELF radiowaves, brain waves, EMR.

As this article is a response to “Solving the “Hard Problem”: Consciousness is an Intrinsic Property of Magnetic Fields” what follows is the introductory paragraph in that article. “It’s widely assumed that consciousness is the phenomenological correlate of a specific process or processes in the brain. Resolving the problem of how consciousness, which we mean as the capacity for subjective experience, appears as a result of brain function (the “hard problem”), is one of the defining questions of contemporary neuroscience. Here, we propose that consciousness is an intrinsic property of magnetic fields. This implies that even a single common magnet would possess a rudimentary consciousness. A natural corollary is that cognitive complexity relies on structural or functional complexity in the magnetic field that supports it”.¹

The author of that statement proposes that “magnetic fields” are a real “physical substance” that generates this “mental phenomenon” that we call “consciousness”. “Hard Problem” solved – QED. But I really don’t think it’s as easy as that. For a start there is the question raised by Eugene Wigner about “The Unreasonable Effectiveness of Mathematics in the Natural Sciences”,² the question raised by Erwin Schrödinger about “What is Life?”,³ the question raised by “Gödel’s theorem”,⁴ and there is the question whether “mind”, “intellect” and “soul” are not

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correlates of or intrinsically related to what we call “consciousness”. It will be argued in this article that the learned author answers none of these questions. However it will be submitted that he has taken a significant step in the right direction for, without apparently realizing it, his article is talking about “electronic phenomena”. In furtherance of his article a model will be presented that consciousness is generated by electronics, that brains are electronic devices, and the brains of all living creatures (including plants) are connected electronic devices.⁵

The Unreasonable Effectiveness of Mathematics in the Natural Sciences

Eugene Wigner defines a law of nature:

All the laws of nature are conditional statements which permit a prediction of some future events on the basis of the knowledge of the present, except that some aspects of the present state of the world, in practice the overwhelming majority of the determinants of the present state of the world, are irrelevant from the point of view of the prediction.²

These laws of nature quite clearly derive from the efforts of human scientists to find some explanation for the extraordinary number of regularities, as well as evidence of design and order, that we find in the universe. Erwin Schrödinger has stated that it’s “a miracle that in spite of the baffling complexity of the world, certain regularities in the events could be discovered” for he feels that “it is not at all natural that "laws of nature" exist, much less that man is able to discover them”. The fact that man has been able to discover them is indeed a “second miracle [that] may well be beyond human understanding”.³

The learned author makes much in his paper of Maxwell’s laws of electromagnetism equations:

In simpler terms, consciousness (the brain’s magnetic field) is constantly influenced by neural electrical activity through the classically-known relationship between magnetic fields and electrical currents. Maxwell’s equations thus offer a mathematical description of the primary interface between “mind and matter”, but not the mind’s overall behavior. What we experience in each moment may be the phenomenological correlate of this field’s most excited, coherent, or information-rich areas or the regions with the most salient information content.¹

Maxwell’s equations are a set of partial differential equations that are the foundation of classical electromagnetism. It is not proposed to have any detailed discussion about mathematics, but everyone can appreciate that in the Cartesian grid there are three axes or directions (xyz). A partial differentiation involves holding one axis constant and differentiating over the other two axes. In other words partial differentiation equations cannot possibly as a matter of commonsense be actual “laws of nature” that explains how electric and magnetic fields operate and interact. In addition there is the philosophical problem with using numbers to describe the

“laws of nature”. The fact is that numbers (whether complex simple positive or negative) are man-made symbols that do not actually exist in Nature. Oswald Spengler in his “The Decline of the West” says: “From this there follows a fact of decisive importance which has hitherto been hidden from the mathematicians themselves. There is not and cannot be, number as such.” Numbers are essentially symbols that have a certain meaning to humans just like words. There is essentially no difference between describing a “natural” process in mathematics and describing it in human language. This is borne out in the learned author’s article when he purports to describe the actual process in the brain in words. It tells us nothing about what is *actually* happening, it merely gives us a human description of what is *probably* happening, just like Maxwell’s equations:

The interface of “mind and body” lies in the interaction of magnetic fields and electrical activity in the brain, as described in Maxwell’s Equations. Patterns of activity in the brain’s electrical system will resonate throughout its magnetic system. The many patterns of neural electrical firing thus reflect an equally diverse set of magnetic signals.¹

Which brings us to Spengler’s other profound insight into mathematics in the natural sciences in general and the differential calculus in particular. It is all mere statistics. That is to say a human prediction of what is likely to happen based on observation. Statistics worked out on a hypothetical Cartesian grid that can’t possibly exist in Nature. Take the simplest differential equation for velocity. It will merely give us the *average* speed of a body between two points on a 2-dimensional Cartesian grid. It says nothing about the actual speed of the body at every *moment* in time in 3-D space (and even the notion of three dimensions is a fiction developed in Cartesian coordinates and does not exist in Nature).

And thus theory becomes a chapter of the Calculus of Probabilities, and in lieu of exact we have statistical methods. Evidently, the significance of this has passed unnoticed. Statistics belong, like chronology, to the domain of the organic, to fluctuating Life, to Destiny and Incident and not to the world of laws and timeless causality... In the "classical" mechanics of Galileo and Newton there would have been no room for them. And if, now, suddenly the contents of that field are supposed to be understood and understandable only statistically and under the aspect of Probability — instead of under that of the a priori exactitude which the Baroque thinkers unanimously demanded — what does it mean? It means that the object of understanding is ourselves. The Nature “known” in this wise is the Nature that we know by way of living experience, that we live in ourselves.⁶

So much for relying on Maxwell’s equations for solving the “hard problem”. The differential calculus does not tell us how natural processes work, it merely tells us how they appear to work for an observer who has a measuring stick and a stopwatch and a pencil and paper to chart the

data on a Cartesian grid. It is the ultimate philosophical impediment to the scientific endeavor. The much touted Laws of Physics are merely descriptive, and not dynamic.

What is Life?

The physicist Erwin Schrödinger delivered two series of lectures “What is Life?” and “Mind and Matter” where he is clearly attempting to explain “life’ and “mind” and “consciousness” in terms of quantum mechanics.³ He actually comes up with a quantum theory of mutation that explains the evolution of all species.⁷ Interestingly he treats the question of consciousness as a question of evolution and he brings up some matters that are relevant to the “hard problem” of consciousness, which it is submitted the learned author in his article cannot explain.

No exposition of consciousness would be complete without alluding to what Schrödinger calls “The Arithmetical Paradox: The Oneness of Mind.” This problem, in a nutshell, is whether there is only one consciousness at work in the world, or whether, as certainly appears to be the case, there are trillions, if all the plants, insects, amoeba and algae – independent self-contained “monads” of consciousness that have the capacity to interact with each other but are in the last resort essentially distinct – are counted. The topic is universal, from the Hindu Upanishads assertion that there is only one cosmic consciousness in which all living creatures share, to the pre-Socratic philosopher Anaxagoras, who stated that there is only one cosmic mind, *nous*, from which all living creatures derive their individual soul. The question is answerable if all life is viewed as the evolution of consciousness, which is synonymous with the evolution of DNA. The DNA represents the single universal consciousness, and all individual consciousnesses are manifestations of it.⁷

This, by the way, is the conclusion that Schrödinger reaches as well. But it is at the level of the individual organism that we find the true arithmetical paradox concerning the oneness of mind. Schrödinger ponders the question why every living cell in an organism (say a human being) contains a complete copy of the DNA for that organism. He quotes Sir Charles Sherrington:

The cell as a component of the body is not only a visibly demarcated unit but a unit-life centered on itself. It leads its own life ... The cell is a unit-life, and our life which in its turn is a unitary life consists utterly of the cell-lives.³

This paradox is particularly striking in relation to the brain, where the cortex is made up of a sheet of trillions of individual cells, each containing a complete copy of the human DNA in the nucleus, so each cell appears to be an autonomous unit; yet somehow this “commonwealth of cells” produces in us the impression of having a unified mind. “Matter and energy seem granular in structure, and so does ‘life’, but not so mind.” Here we have one mind based ostensibly on many cell-lives; the only explanation Schrödinger could offer is that there must be a “sub-mind” associated with the individual cells that enables them to act perfectly in concert to produce a unified effect. He immediately dismisses this notion of a sub-mind in every living cell as an

“absurd monstrosity.” However, it is for every living cell, not just those of the brain, that this paradox arises. All living creatures consist of individual autonomous cells, whether one or millions or trillions, which act in concert to produce a unified effect. The solution to the paradox is that it is the DNA that acts as the “sub-mind.” DNA is consciousness – at the cellular level – which explains why there must be a complete copy of the DNA in every living cell. I conclude this section with Schrödinger’s comments on the beginning of consciousness. After favorably noting Sherrington’s observation that the human mind arrived comparatively recently, that is to say very late in the story of evolution, Schrödinger says:

It would seem queer, not to say ridiculous, to think that the contemplating, conscious mind that alone reflects the becoming of the world should have made its appearance only at some time in the course of this “becoming,” should have appeared contingently, associated with a very special biological contraption which in itself quite obviously discharges the task of facilitating certain forms of life in maintaining themselves, thus favoring their preservation and propagation: forms of life that were late-comers and have been preceded by many others that maintained themselves without that particular contraption (a brain). Only a small fraction of them (if you count by species) have embarked on “getting themselves a brain.” And before that happened, should it all have been a performance to empty stalls?³

Evidence that all living cells have some basic consciousness is offered by the fact that decapitated flatworms turn away from light: deprived of eyes they can still “see” and deprived of a brain they can still display purposeful behavior.⁸ One of the authors of the report is quoted as saying: “It’s a fascinating coincidence that decapitation–regeneration experiments appear to copy – chronologically, at least – what may have occurred in evolution.”

Perhaps the most glaring defect in the learned author’s theory that consciousness is the property of magnetic fields is that he completely ignores the role of the DNA in the evolution and generation of consciousness. The fact is that there is a massive amount of electromagnetic activity occurring in the genome that is almost certainly contributing to the on-going processes in the neural circuits in the brain.⁹ With the operation of the genome left completely unexplained, the learned author’s claim to have resolved not only the ‘hard problem’ of consciousness but also some of the big questions such as Descartes’ ‘mind-body’ dualism and solipsism rings hollow and false.

Gödel’s Theorem

But now we have another problem with this word “prove”. An abstract system of mathematics has been used to prove that the human brain is an “electromagnetic” machine. Let’s state it as a theorem: Consciousness (the brain’s magnetic field) is constantly influenced by neural electrical

activity through the classically-known relationship between magnetic fields and electrical currents. Maxwell's equations thus offer a mathematical description of the primary interface between "mind and matter". Can we prove this theorem. We now need to ask whether Gödel's incompleteness and self-reference problems apply to the human mind itself and to the system of abstract mathematics called Maxwell's equations for electromagnetism. If we obtain an affirmative answer to either of these questions then this theorem will remain forever unprovable, no matter how many times it is conducted and the results found to be 100% reproducible.

We shall turn to the hardest question first. Is the human mind a machine, and in particular a Turing-machine. This question arises as a result Gödel's first incompleteness theorem which says that for any consistent formalized system F , which contains elementary arithmetic, there exists a sentence G_F of the language of the system which is true but unprovable in that system. Gödel's second incompleteness theorem states that no consistent formal system can prove its own consistency.⁴ Many eminent logicians and philosophers, including Gödel himself, take an anti-mechanist view of the human mind. The argument assumes that for any formalized system, or a finite machine, there exists the Gödel sentence (saying that it is not provable in that system) which is unprovable in that system, but which the human mind can see to be true.⁴ Generally speaking they state that the human mind infinitely surpasses the power of any finite machine, and the human mind is consistent in the sense that the human mind will always be able to see that an unprovable statement is actually true.

This is the problem of self-reference par excellence. The human mind is attempting to determine whether it is a machine or not. In other words it is trying to look at its own programming, or alternatively it is trying to state unequivocally that it doesn't have any programming. Let us take the two contradictory statements. The human mind is a machine; the human mind is not a machine. Both those statements are unprovable, and the fact that so many great minds over the past 80-90 years have taken different views which one of them is true puts paid to the assertion that the human mind is always able to see that an unprovable statement is true. They are simply not able to assert that the human mind surpasses a mere machine because it will always determine intuitively whether a statement is true or not. As Martin Davis has put it : "Insight didn't help".¹⁰ Paul Benacerraf in an article with the illuminating title "God, the Devil and Gödel" sums up the situation succinctly: "If I am a Turing machine, then I am barred by my very nature from obeying Socrates' profound philosophical injunction : *Know thyself*".¹¹

Mind, Intellect, Soul

The learned author claims to have resolved the issue of Descartes' dualism by claiming that consciousness is neither 'mental' nor 'material' but is rather 'energy'. It's universally accepted since Einstein's famous equation ($E = mc^2$) that energy and mass are synonymous concepts. In fact this proposition is questionable on the basis of the unreasonable effectiveness of mathematics in the natural sciences – physicists don't actually know what 'mass' is and the

velocity of light is actually an average or statistic and is not a natural force per se – but we may essentially agree with him nonetheless for he concludes:

“Energy” is the capacity of the body or system enabling it to do work. “Work” is anything that alters or tends to alter the point of application of a force. A “force” is anything that alters or tends to alter a body or system’s state of uniform motion in a straight line or “rest” (inertia).

However we can’t agree that this energy is the magnetic field per se, but is rather in the form of ‘electronics’, which means that the brain is an electronic device that generates consciousness. We then may express complete agreement with his assertion that consciousness cannot exist without a brain to generate it. And the same can be said if we choose to consider consciousness as ‘mind, intellect or soul’. In this way we can completely avoid all the ‘big questions’ in Philosophy and simply assert that our brain has an operating system (OS) that enables programs that generate in us a conscious mind, an unconscious mind, dreams and intelligence.

It’s not disputed by anybody that we have a conscious mind and an unconscious mind. Freud asserted that “dreams are the royal road to the unconscious” and the same electronics that generates our consciousness is obviously capable of generating our dreams. Likewise the same electronics that generates our consciousness is capable of generating our intelligence or intellect. As regards the question of soul we cannot improve on the conclusion of Willam James in his *Varieties of Religious Experience*. Western science has had a scientific and psychological explanation for the unconscious soul for more than 100 years. James says:

The subconscious self is nowadays a well-accredited psychological entity; and I believe that in it we have exactly the mediating term required. Apart from all religious considerations, there is actually and literally more life in our total soul than we are at any time aware of. What Mr. Myers said in 1892 in his essay on the Subliminal Consciousness is as true as when it was first written: “Each of us is in reality an abiding psychical entity far more extensive than he knows – an individuality which can never express itself completely through any corporeal manifestation. The Self manifests through the organism; but there is always some part of the Self unmanifested; and always, as it seems, some power of organic expression in abeyance or reserve.” Let me then propose, as a hypothesis, that whatever it may be on the farther side, the ‘more’ with which in religious experience we feel ourselves connected is on its hither side the subconscious continuation of our conscious life.¹²

We are an “abiding psychical entity” because both our conscious mind and our unconscious mind are generated by electronics. And indeed we may be able to shed some more light on the question of soul if consciousness is generated by electronics. Aristotle says in *Generation of Animals* that “the parts around the head and eyes appear largest in embryos at the start, and this is the origin of the being” that is to say our soul or ‘first actuality’.(742b12-17) The fact is that

by five weeks after fertilization the embryo cranium is bulging with midbrain that is firing spontaneously.^{13,14} That is to say it is emitting brainwaves and it is now settled beyond doubt that brainwaves are radiowaves that carry information.¹⁵ It is a fair bet that our soul is located in the midbrain. Also the midbrain is responsible for the saccadic eye movements in our dreams (REM sleep).¹⁶ Whether you want to call it soul or unconscious mind is immaterial. The fact is it is generated by electronics.

The magnetic properties of the brain

The link between magnetism and radiowaves is amply demonstrated by Magnetic Resonance Imagery (MRI) which is a commonplace in medicine and industry. Basically the nucleus of an atom in a strong magnetic field will emit radiowaves when perturbed by a weak oscillating magnetic field. The radiowaves are then detected to form an image. MRI brain scans normally detect the nuclear resonance of the hydrogen atom which is prevalent in water and fat in the brain, but in the future MRI scans will detect the nuclear resonance of Biogenic Magnetic Nanoparticles (BMNPs) which is magnetite (a metal oxide Fe_3O_4).¹⁷

At this point we may quote the learned author's basic thesis:

The seven billion magnetite crystals in an average brain, and the magnetosomes they comprise, produce multiple fields, but they're also components of the brain's larger magnetic field, with two (hemispheric) loci, and constantly changing regions of peak magnetic field strength. We propose that consciousness is a property of this magnetic field, and the functions associated with regions of peak magnetic field strengths or the most salient magnetic information will correlate with the content of consciousness. This agrees with the principle that the phenomenology of the most metabolically active neural regions (in either excitation or inhibition) correlate with the present content of the 'mind'.¹

So our learned author is on the right track but he doesn't seem to know where the track is leading to. He states in his article "Any quantum-level basis for consciousness would only be an instance of a larger quantum basis for all magnetic fields, and any quantum mechanics of consciousness would resolve into special cases of the quantum mechanics of magnetic fields." This is a perfectly true statement for magnetism in general involves electron spin and MRI involves the spin of the nucleus which is essentially quantum phenomena. But he doesn't seem to realize that he claims to have solved the "hard problem" of consciousness with an even harder problem. What is quantum mechanics telling us about the real physical world? The learned author has ignored the sage admonishment by Niels Bohr: "Anyone who is not shocked by quantum mechanics has failed to understand it." Which leads us to following statement by the learned author:

However, consciousness would still be present with only one percept, even with no "self" to interpret it, since we have posited that even a simple magnet will have a rudimentary consciousness, as will a bacterium with a single magnetosome.¹

A bacterium with a single magnetosome – most certainly because it has DNA in it. A simple fridge magnet or a horseshoe magnet – not so much. We don't actually know what magnetism is nor what magnetic fields are.

It has been proposed that these BMNPs are the precursor of the protein ferritin which is ubiquitous in the brain and body.¹⁸ Which brings us to Radiogenetics and Magnetogenetics. It has been found that low frequency radiowaves act on the ferritin in the brain and body in exactly the same way as magnetic fields. The ferritin in turn opens ion channels in the membrane of the cell to activate genes.^{19,20} I can't stress this enough. EMR acts in exactly the same way as a magnetic field. All research reports about the effects of EMR on biological processes therefore comes under the heading of magnetism. Here I can only list a few instances. Low frequency radiowaves affect the expression of the cFos proto-oncogene.²¹ ELF radiowaves in this case 50Hz affect the methylation of the DNA, that is to say epigenetic factors.²² And there are many research papers where ELF radiowaves affect cellular and genetic processes, including 'calcium flux' which means it triggers electrical activity by opening ion channels.²³

Ferritin is paramagnetic and magnetite crystals are superparamagnetic. Paramagnetic means they become magnetized when placed in a magnetic field and revert to their normal state when the field is removed. From the discussion above about Radiogenetics and Magnetogenetics it is clear that low frequency radiowaves also cause the ferritin and the BMNPs to become magnetized. In the case of the BMNPs that are superparamagnetic their magnetic sensitivity is much higher than ferritin so they will react to ELF radio waves.²⁴ Indeed there is a whole field of research, Superparamagnetic relaxometry (SPMR), devoted to measuring the magnetic moment of these BMNPs using Superconducting Quantum Interference Detectors (SQUIDS).²⁵ The relaxation times of these BMNPs carry information. These SQUIDS are used in Magnetoencephalography (MEG) to make inferences about the neural activity in the brain, and they basically rely on the relationship between magnetic fields and electric currents called 'magnetic flux'.²⁶

The key to it all is this magnetite (Fe_3O_4)(BMNPs) which is superparamagnetic. ELF radiowaves (brain waves) will cause it to become magnetized. This magnetic flux in turn causes sodium (Na^+) ion channels in the vicinity to open and a current will flow. This depolarizes the neuron. Then the electric flux magnetizes the BMNPs and this magnetic flux opens other ion channels to cause a current of potassium (K^+) ions to flow out of the cell which repolarizes the neuron. The 'spike' is a combination of magnetic flux and electric flux i.e. classical electromagnetism i.e. Maxwell's equations, to which the learned author specifically alludes.

The electrical properties of the brain

At the outset, I would just like to elucidate a general misconception about radio emissions. It is widely believed that the golden years of radio ended in the 1950s or thereabouts and that radio transmissions only involve the transmission of audio signals, principally voice and music. The fact is that all of modern electronics that involves the transmission of information via EMR (electromagnetic radiation) are simply different aspects of radio transmissions, including television, cell phones, Wi-Fi, remote control devices, radar, GPS navigation, and wireless Bluetooth devices. If the information is being transmitted by EMR, it's a radio. The radio spectrum extends from Extremely Low Frequency (ELF) waves from 3-30 Hz thru to Tremendously High Frequency (THF) from 300-3,000 THz (one THz is one trillion cycles per second) which ends somewhere in the UV range, even higher than visible light. It's an undisputed fact that human brainwaves are in the same range as the ELF waves, and from the point of view of this paper are considered to be radiowaves. The definition of an electronic device is that it generates radiowaves for the purpose of communication, which means that the human brain is an electronic device.

In Nature there is only one fundamental force that is relevant to this issue and that's the electromagnetic force, and the apparent plethora of different forms of energy that are at work in Nature are all actually just different aspects of this one fundamental force – electricity, bioelectricity, chemoelectricity, electromagnetic radiation (EMR), electromotive force (EMF), magnetic fields, electronics to name only the main headings. These all then have subgroups like alternating current (AC) direct current (DC), all the different frequencies of EMR, integrated circuits and semiconductor and nano technology in electronics that involve quantum mechanics, and geomagnetics, biomagnetics, electromagnetics etc. The point is that they are all just different aspects of the fundamental electromagnetic force, and under different conditions they generate each other. For instance a moving magnet will generate electricity, an electric current creates a magnetic field as well as electrons lining up in metals, an alternating current (AC) emits radiowaves (EMR) at the same frequency as the current, and an electric current in a coil around a stationary piece of metal will cause it to become a magnet and will spin a magnet to create a mechanical force, biophotons which are EMR are spectral lines of atoms emitted from a semiconductor when the electrons fall back from the conduction band to the valence band. The essential point for the purpose of this article is that brainwaves are ELF radiowaves and so they are just one aspect of the electromagnetic force and are emitted by an alternating current (AC) in the brain. And the fact that the brain emits radiowaves means that it can actually receive radiowaves as well. The brain can act as an antenna. Later in this article I present a model of the brain as a wirelessly connected electronic device and I list the various ways the brain emits (and receives) these ELF radiowaves.

ELF radiowaves are virtually unstoppable. They will go thru mountains and will circle the Earth several times.²⁷ Higher frequency radiowaves will be quickly stopped in a 'lossy' medium such as water, but they can use ELF radiowaves for communication between submarines under water.

There is no reason in principle why ELF brain waves could not be received by another brain miles away. As the learned author points out: "If the signals in neuromagnetic fields are the same for all humans, then at least some human brains have the potential to directly communicate with each other, though we should not expect that all brains will be equally sensitive to this subtle stimulus."¹

The principal way that alternating or oscillating current is generated in the brain is thru depolarization and repolarization of the cell. This results in an electrical 'spike' where ion channels open in the membrane of the cell and positively charged sodium ions enter the cell followed by positively charged potassium ions exiting the cell. Neurons are connected by axons and these 'spikes' travel along the axon as action potentials as positively charged ions enter and exit the membrane.²⁸ These spikes are essentially an alternating current (AC) and they will emit ELF radiowaves (brain waves). We have seen above that ELF radiowaves can initiate these spikes thru the interaction of magnetic and electric flux, which means that the neurons act as a transmitter and receiver of ELF radiowaves.

There are other potential gradients in the membrane of the cell as well. Microtubules are of nanoscale dimensions in diameter and they have a positive and negative end, that is to say they contain an electric field. It is a moot point whether these microtubules actually conduct electricity, but according to the Orch-OR theory of Penrose-Hameroff these microtubules contain highly ionized water which will generate a current in an electric field.²⁹ The Orch-OR theory states that the 'quantum vibrations' in these microtubules generate EEG beat frequencies, but it is more likely that the current in these tubes of nanoscale dimensions will emit ELF radiowaves as well as cause quantum vibrations.

In addition there are microfilaments in the membrane of the cell which are nanowires that do conduct electricity. They will be contributing to the various potential gradients in the membrane, and thus to the generation of the electrical 'spikes'.³⁰ It is also known that there is Trans-Plasma Membrane Electron Transfer (tPMET) which undoubtedly occurs as a result of the potential difference between the interior and exterior of the cell, and thus will contribute to these 'spikes'.³¹

Now-a-days there are any number of Brain Computer Interfaces (BCIs) and other neural prosthetics on the market where brain waves are used for communication with connected electronic devices.³² There are research papers in optogenetics where brain waves have been used to affect the expression of genes.³³ People are actually playing computer games using only their brainwaves to communicate their thoughts.³⁴ We have even seen the start of 'mind-reading' technology where brain waves are being translated into recognizable words.³⁵

A model of the brain as an electronic device

By way of conclusion, we can now go further than the learned author who basically asserts that consciousness is generated by the magnetic fields in the brain interacting with the electrical activity in the brain, and conclude that what he is stating is that the brain is an electronic device: that consciousness is generated by electronics, and the brains of all living creatures are connected electronic devices. For a start the neural network is basically an integrated circuit. The neurons are logic gates that are either 'on' or 'off'. When the neuron is on an action potential proceeds along the axon. These action potentials or electrical 'spikes' are generated in the following ways. 1. Positively charged ions depolarize and repolarize the neuron and then ions pass thru the membrane of the axon as the action potential proceeds; 2. Electrical current in the microtubules and microfilaments in the membrane of the cell contribute to the EEG beat frequencies; 3. Trans-Plasma Membrane Electron Transfer (tPMET) occurs as a result of the oscillating potential difference between the interior and exterior of the cell. The specific neurons that fire generate ELF radiowaves (brain waves) of a specific frequency that carry information (signals) internally to the neural network and externally to other brains (connected devices). Normally the signals will be received unconsciously by other brains, but they can be boosted in which case they will be received consciously.

To quote from the abstract of the learned author: "The "hard problem," the question of the physical basis of consciousness, finds a solution in the hypothesis that consciousness is an attribute of magnetic fields, and that complex consciousness (which can include 'self-awareness', intelligence, or social interaction) is based on the integration of the brain's magnetic field (originating from its rich population of magnetite crystals) with its neural electrical system."

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