TUNING THE MIND IN THE FREQUENCY DOMAIN:

KARL PRIBRAM'S HOLONOMIC BRAIN THEORY AND DAVID BOHM'S IMPLICATE ORDER

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ABSTRACT: It is proposed that consciousness manifests as modulated radiant electromagnetic energy resonating in and between two regions, an explicate space-time order and a nondual implicate order. In such a model, the range of human consciousness is a function of the bandwidth of mind in the frequency domain. The hypothesis emerges from an integration of two paradigms: (1) the holonomic mind/brain theory of Karl Pribram, and (2) the ontological interpretation of quantum theory by David Bohm. The composite model, known as the Pribram-Bohm holoflux hypothesis, addresses observed phenomena of non-locality, both spatially and temporally.

Holoflux is a term suggested by Karl Pribram to describe David Bohm's "holomovement" of information-energy cycling between an outer explicate order and an interior implicate order. Bohm concluded that consciousness will eventually be found as *primary within the actuality of the implicate order*. Pribram's decades of laboratory data, collected over the course of decades, convinced him that memory storage and retrieval follows a holographic Fourier process of transformation between frequency and time domains (i.e., simultaneous resonance between frequency spectra observed within the implicate and explicate orders).

This Pribram–Bohm composite holoflux theory is congruent with established principles of radio communication engineering. In Bohm's explicate space-time domain, the holoflux spectra manifest as electromagnetic shells of information, or isospheres. Each isosphere has a unique tunable wavelength equal to its diameter, and each isosphere is separated by one Planck length. Information imprinted on the holosphere resonates with the nonlocal holoflux within the implicate order. This is outside of space-time, located at the bottom of space, and beginning below 10^{-35} m.

Extending the panpsychist paradigm that consciousness is inherent in the structure of the universe, the holoflux theory describes a single, dynamic, nondual but tunable energy. This energy cycles mathematically, in a lens-like process of transformation between the two domains, the explicate order and the implicate order.

KEYWORDS: Mind; Karl Pribram; David Bohm; Holoflux; Holonomic Brain Theory; Implicate Order

INTRODUCTION

To the physicist David Bohm (1980), the larger universe, referred to as "the Whole," consists of two domains, an implicate order and an explicate order. Bohm's explicate order is congruent with what is frequently referred to in physics as space-time, the familiar region sensed by human beings primarily through the qualia of vision and hearing. Space-time consists of four dimensions: three dimensions of space (height, width, and length) plus a single dimension of time. Contemporary physics asserts, however, that there are more than these four dimensions. Einstein himself, in developing his general theory of relativity, demonstrated that it takes ten numbers tracking ten fields or dimensions, to describe fully the mathematics of gravity (Yau and Nadis 2010, 10).

While classical Newtonian physics has focused solely within an exploration of the four dimensions of space-time (height, width, length, time), quantum physics has begun to seek data implicating additional dimensions outside of space-time. But where are such dimensions to be sought? Are they perhaps outside of, other than, or even *beyond* space and time? Proponents of quantum string theory describe these additional dimensions as being extremely small, telling us that they are somehow "curled up" just outside of space-time (Klein 1991). As is often the case, trying to use language to describe mathematics becomes paradoxical and imprecise; using the attributes of size ("large," "small," etc.) for these non-spatial dimensions may be self-contradictory. Nevertheless, in 1926 the Swedish physicist, Oskar Klein, calculated that the size of one of these dimensions could be no larger than 10^{-30} cm, slightly above the Planck length length limit of 10^{-33} cm (Klein 1991, 110).

In 1995, a physicist in southern California, Edward Witten—building upon the work of Einstein and Klein—proposed an eleven dimensional structure to completely describe the universe as a "Whole" (Witten, 1995). Witten's model has come to be known as "M-theory" (generally taken to stand for "membrane," "matrix," "master," and alternately, in a spirit of levity, as "mother," "monster," "mystery" and "magic"; see Duff 1996). Whitten developed the mathematics of M-theory upon the initial assumption that the fundamental constituents of reality must be tiny "strings" of Planck length (at 10^{-33} cm) that exhibit rotational vibration at quantum resonant frequencies (Yau and Nadis 2010, 124).

A representational topology of the missing seven dimensions was developed by mathematicians Eugenio Calabi and Shing-Tung Yau in what has come to be known as the Calabi-Yau manifold, depicted in Figure 1. Represented here is a geometric model of these missing seven dimensions at spatial scales below the Planck length. Note that the different shaded regions in the image represents the seven distinct dimensions beyond the four associated with space-time.

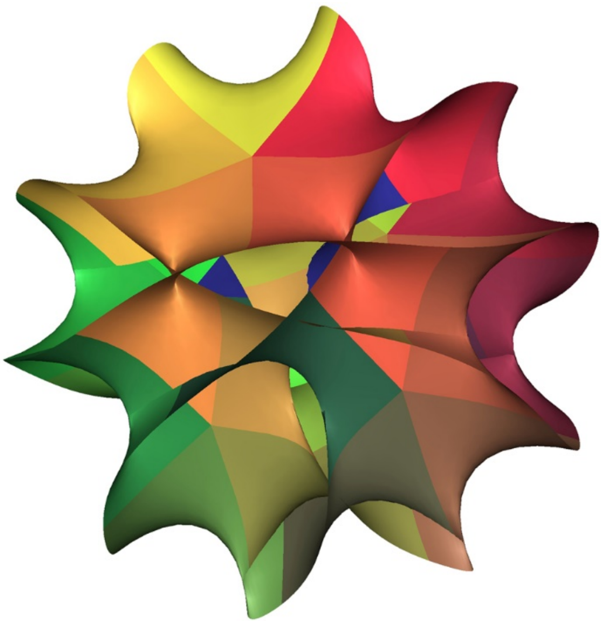

Figure 1. Calabi-Yau Manifold. Graphic by Ronhjones (2014). Retrieved from Wikimedia Commons.

While the Calabi-Yau manifold is a representation that includes the "missing dimensions" beyond the simplified geometry of Whitten's "string," Bohm sees the explicate order of space-time as ending *below* the spatial dimensions bounded by the Planck length diameter, (i.e., below the inner surface of spherical shells of Planck length diameter of 10^{-33} cm). This internally bounded region, referred to as a Planck holosphere or quantum black hole, is shown in Figure 2, where a Calabi-Yau manifold can be seen superpositioned at the center within the bounding locus of a such a quantum black hole (Joye, 2016).

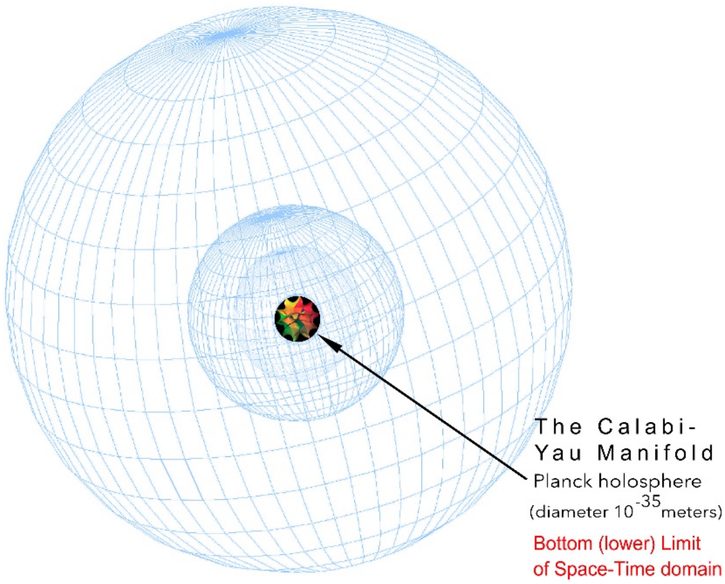

Figure 2. Calabi-Yau Manifold superpositioned within bounding Planck holosphere. Graphic by author.

Shing-Tung Yau, who proved the mathematical existence of the Calabi-Yau manifold, describes John Wheeler's concept of quantum foam in "the idea that what might appear to be a smooth, featureless object from a distance can look extremely irregular from close up" (Yau and Nadis 2010, 315–14). This supports Bohm's conjecture that a quantum potential wave is generated by the spin turbulence and quantum foam occurring as boundary conditions of these quantum black holes which separate space-time from nonspatial, nontemporal dimensions of the implicate order. This quantum potential at sub-quantum levels influences the structure of the explicate order and acts to generate a holonomic, fractal universe manifesting in space-time (Bohm, 1980).

FIELDS, FREQUENCY, AND THE FREQUENCY DOMAIN

An understanding of fields and frequency, and their measurement and dynamics, are of central importance to an understanding of how the holoflux field of consciousness applies electromagnetics in space-time to tune the mind. Pribram's experimental data convinced him that vision and other sensory systems operate through a holographic process, and so he developed what he termed the *holonomic brain theory*, postulating the importance of the *frequency domain*:

> Essentially, the theory reads that the brain at one stage of processing performs its analyses in the *frequency domain* . . . a solid body of evidence has accumulated that the auditory, somatosensory, motor, and visual systems of the brain do in fact

> process, at one or several stages, input from the senses in the *frequency domain*. (Pribram 1982, 27–34).

It was Michael Faraday (1791–1867) who first conceived of the reality of an invisible electromagnetic "field" during his observation of magnetic lines of force around a conductor carrying a direct current (Crease 2008, 135). While Faraday had the ability to conceptualize a certain ontological reality, he did not have sufficient mathematical training to formalize the dynamics of his theorized field. Thus it was in 1861 that James Clerk Maxwell (1831–1879; see Figure 3), through a series of interlocking equations subsequently known as the "Maxwell equations," was able to model the dynamics of electric and magnetic energy in waves of various frequencies, flowing through space–time in an ocean of vibrating flux (Cook 2002).

Figure 3. James Clerk Maxwell at Trinity College, Cambridge. Graphic by Tjlaxs (2005). Public domain image published in the US before 1923. Retrieved from Wikimedia Commons.

His discovery was based upon his development of a set of four interlocking partial differential equations with which he was able to predict the dynamics of electric charges and how they are generated by oscillating magnetic fields. Ironically, though Maxwell's equations predicted electromagnetic waves, their existence was not accepted until nearly 25 years later, when Heinrich Hertz (1857–1894), through various experiments, was the first to detect electromagnetic waves (Hertz 1893). Nevertheless, Hertz was forever in awe of Maxwell's equations which had led him to this discovery. Here he speaks, with almost mystical reverence, of the "wisdom" that he has found in Maxwell's work:

> One cannot escape the feeling that these mathematical formulae have an independent existence and an intelligence of their own, that they are wiser than we are, wiser even than their discoverers, that we get more out of them than was originally put into them. (Bell 1937, 16)

In the 1800s, electromagnetic frequencies were measured in units of "cycles per second" and data was recorded in units of "c/s," (i.e., "cycles/second"). This convention was continued for many decades into the twentieth century until the development of quantum mechanics, when calculations involving frequency using Fourier and Laplace transforms were discovered to violate the rules of dimensional analysis if a time dimension were included. Accordingly the International Electrotechnical Commission officially dropped the misleading units of "cycles/second," and renamed the unit of frequency "Hertz" to honor the discoverer of electromagnetic frequency waves (Ruppert 1956). Karl Pribram, commenting on the confusion, here suggests using the term "spectral density" in lieu of the term "frequencies":

> When we deal with a spectrum of frequencies per se, we often substitute the term "spectral density" to avoid a common confusion that Gabor pointed out in his paper: non mathematicians, even physicists, often think of frequencies as occurring only in time, but when mathematicians deal with vibrations as in the Fourier transform, frequencies are described as composing spectra and devoid of space and time. (Pribram 2013, 105)

Unfortunately, this mistake of conceptualizing frequencies in terms of "cycles per second" has been a continued cause for confusion. Ken Wilber, in reviewing Pribram's work in *The Holographic Paradigm*, bases his rather strong criticism of the holonomic theory by assuming frequency "means cycles per second":

> The transform of "things" into "frequencies" is not a transform of space/time objects into space/time frequencies. Frequency does not mean "no space, no time"; it means cycles/second or space per time. To read the mathematics otherwise is more than a quantum leap; it is a leap of faith. (Wilber 1982, 181)

SINE WAVE AND FREQUENCY IN THE MOTION OF AN EXOPLANET

Keeping in mind that frequencies exist **both** in a *space-time domain* as well as in a nonspatial, nontemporal *frequency domain*, it is useful to visualize the path of a sine wave in space and time. Assume that we are measuring the brightness of an exoplanet circling around a distant star, and that we are viewing it almost edge-on to its planar orbit. When the planet is closest to us, it will appear brightest to us, but when it is furthest from our viewing point it will appear maximally dim. If we were to plot the intensity of this visual image of an exoplanet over the period during which it makes one orbital cycle, it would appear, graphed on two-dimensional Cartesian coordinates, as the sine wave in Figure 4. The points where the graphed wave crosses the zero axis corresponds to the exoplanet being at right angles to its star and our vantage point.

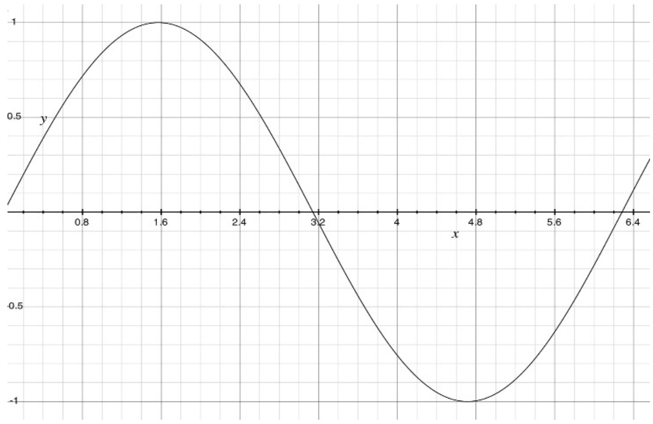

Figure 4. A sine wave. Graphic by author.

According to the Bohr model of atomic theory, electrons spinning around their nuclei emit similar sine wave patterns as they orbit, and accordingly, space–time is replete with sinusoidal electromagnetic waves of an almost infinite number of different frequencies, corresponding to orbiting photons (Baggott 2011, 30). The frequency of radiation emitted is the inverse of the orbital time; for example, an orbit that takes one second to complete would emit electromagnetic radiation of 1 Hz, while an orbit of an electron with smaller radii would emit correspondingly higher frequencies of radiant of energy. Simply put, the closer to the center the electron is, the faster its orbit, and correspondingly, the less time expended to complete the orbit..

The wavelength of a sine wave is a measurement of the distance, in space, between any two points with the same phase of a frequency, such as between troughs, crests, or zero crossing in the same direction. Figure 5 illustrates the concept of wavelength, depicting the graph of a sine of wavelength λ.

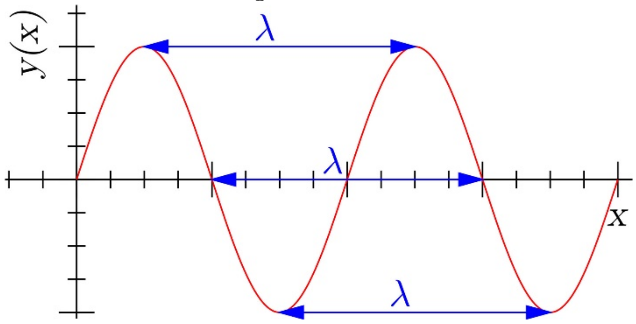

Figure 5. Wavelength. Graphic by Richard F. Lyon (2009). Reprinted under the terms of a Creative Commons Attribution ShareAlike 3.0 Unported license. Image retrieved from Wikimedia Commons.

Frequency charts of radiant electromagnetic energy are commonly depicted as a spectrum displayed using two-dimensional Cartesian coordinates with named ranges. Some of these are listed in Table 1, "Ranges of the Measured Electromagnetic Field." It should be noted however that the entire wavelength spectrum of the universe ranges from a maximum at the diameter of the universe at 10^{27} meters down to the Planck length of 10^{-35} meters. To span this total range requires 62 "power of ten" leaps.

Table 1

Ranges of the Measured Electromagnetic Field

Named range	Approximate wavelengths	Frequency (Hz)
Radio waves	10^3 or 1 kilometer	10^6
Microwaves	10^0 or 1 meter	10^9
Infrared	10^{-8} meters	10^{13}
Visible light	10^{-9} meters	10^{14}
UV rays	10^{-10} meters	10^{16}
X rays	10^{-11} meters	10^{18}
Gamma rays	10^{-12} meters	10^{19}

Note. Data adapted from Benenson et al., *Handbook of Physics*, 227.

INFRARED ELECTROMAGNETIC RADIATION

The ubiquitous word "heat" tends to confuse an actual phenomenon with an epiphenomenon. The actual sensation termed "heat" is a measure of human neurosensory reaction to the physically radiant energy phenomenon of electromagnetic energy interacting with neurons in the skin cells. The actual energy in question is invisible electromagnetic radiation in the infrared band of the spectrum. Similarly, when we use the word "light," we tend to fall into the same potentially specious obfuscation. The term "light," like heat, pertains to the bio-sensory phenomenon of visual perception, while the primary phenomenon is actually pure radiant electromagnetic energy, precisely the same kind of energy as "heat," though of a higher frequency (a shorter wavelength) in the significantly broader electromagnetic spectrum (Feynman, Leighton, and Sands 1964, 72).

What is less commonly considered is that the living human body itself broadcasts a unique, narrow spectrum of electromagnetic radiation in the infrared band of radiation (Becker and Selden 1985). Wien's Law (Equation 1 below) states that the maximum electromagnetic wavelength generated by a theoretically perfect "black body" at a specific given temperature is calculated as follows:

$$\lambda_{\mathbf{max}} = \frac{b}{T}$$

Equation. Wien's Law (Feynman, Leighton, and Sands 1964, 74). Graphic by author.

Here "b" in the equation is a constant discovered by Wilhelm Wien in 1893 and is equal to 2.897768551 x 10^3 m K, and T is the temperature (Crease 2008, 128). If we substitute the core human body temperature of 98.6 F for T, we obtain the maximum wavelength to be 9.34 micrometers. Electromagnetic energy vibrating at this wavelength lies within the range of the infrared region, just below the range of humanly visible light frequencies; the human body glows with approximately 860 watts of infrared radiation, commonly termed (and perhaps misleadingly), "heat." It is of interest to note that this electromagnetic radiation generated by human bodies peaks at a wavelength of 9.34 microns, approximately five times smaller than the diameter of a human hair, but identical to the diameter of a human red blood cell (Becker 1990).

Energy vibrating in the infrared band of radiation has a unique relationship with water. It is within the infrared range that water molecules exhibit their maximum transmittance or transparency to electromagnetic radiation, as can be seen in Figure 6, "Water Response to Infrared Electromagnetic Radiation." A sharp dip in the absorption coefficient of atmospheric water vapor is apparent in the graph at about 10 microns on the horizontal axis. Such a dip is what communication engineers call a "passband." Earth's atmosphere exhibits a passband to radiation in the 10 micron range; it is important to note that this atmospheric passband closely matches the human peak wavelength of electromagnetic radiation, previously calculated as 9.34 microns (Warren and Brandt 2008, 1049).

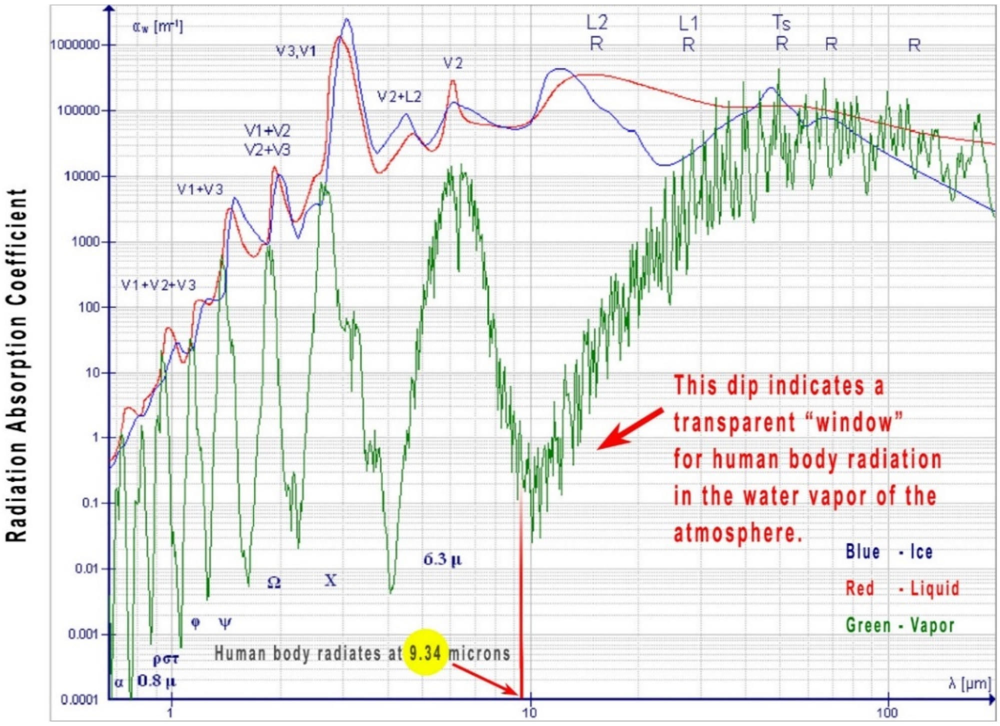

Figure 6. Water response to infrared radiation.[1] Annotation added by author to image by Darekk2 (2012). Reprinted under the terms of Creative Commons Attribution Share Alike 3.0 Unported. Image retrieved from Wikimedia Commons.

If the dynamics of human consciousness has evolved to broadcast and receive in this frequency range, then it would be convenient if indeed the atmosphere of our planet is transparent in this range. Indeed it is so, for at 9.34 microns, the atmosphere—with its gasses and water molecules—does not absorb radiant energy but instead allows it to pass relatively unrestricted and unattenuated into and throughout the biosphere. This passband in Earth's atmosphere can be seen at the center of a graph of atmospheric electromagnetic opacity by wavelength, plotted by NASA (Figure 7).

[1] Water absorption spectrum; absorption coefficient for water—liquid (red line), vapor (green) and ice (blue) between 667 nm and 200 μm (red and most important part of infrared).

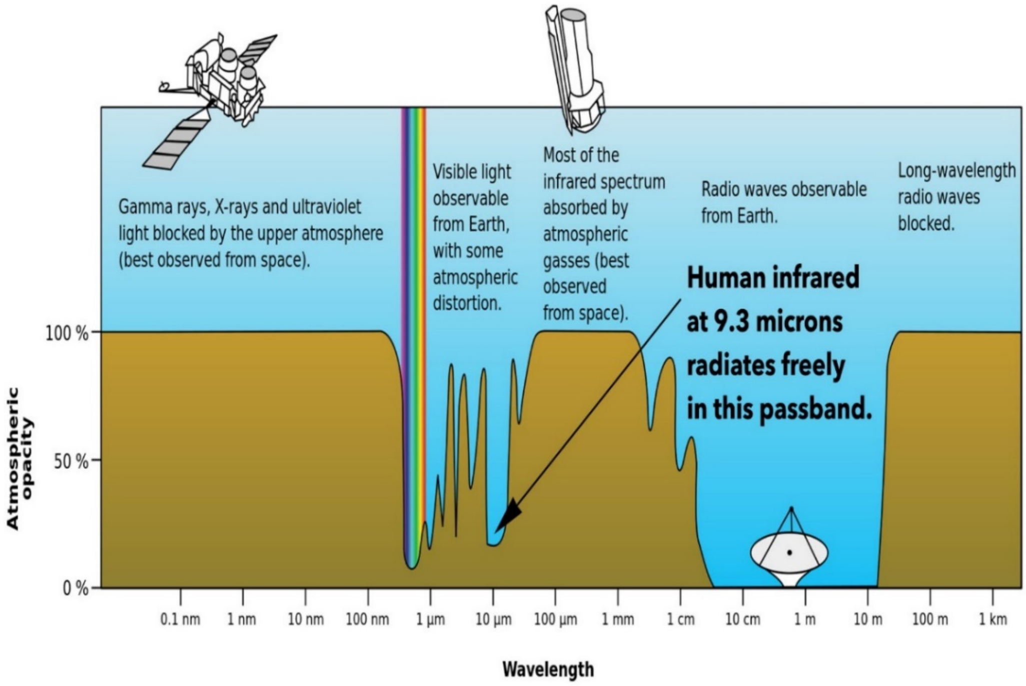

Figure 7. Atmospheric electromagnetic opacity. Annotation added by author to NASA image by Mysid (2008). Public domain image retrieved from Wikimedia Commons.

As early as 1939 military engineers began exploiting the fact that the electromagnetic radiation emitted by human bodies is transparent to the atmosphere. This realization enabled them to develop electro-optic night vision devices specifically to observe human infrared radiation travelling through the atmosphere at wavelengths between 9 and 10 microns (Clark 1939, 78).

Water molecules themselves, as vapor in the atmosphere, may act as magnetically resonant dipole "highways," providing infrared channels and currents in the air, even among the clouds. One can imagine the possibility of a system of natural electromagnetic bio-networking around Earth's globe. Such bio-communication possibilities for human infrared radiation have been widely ignored in the neuroscience community, where such energy is understandably dismissed as "heat," "noise," or "random thermodynamic activity." The current focus continues to be primarily upon the search for bands of human consciousness within the relatively slow "brain-wave" frequency regions recorded by scalp-affixed electroencephalographic (EEG) sensors, generally detected in a range from 8 Hz to 50 Hz (Nunez 2010, 104–5).

In contrast to this low frequency range (8–50 Hz) of electromagnetic radiation detected by sensors on the exterior of the human scalp, the human body continuously radiates, internally and externally, in the “thermal infrared” or “long-wavelength infrared” band. This energy is tuned to wavelengths from 8–15 microns, in a frequency range from 27–30 THz (1 THz = 10^{12} Hz). Table 2 compares the detected ranges of human EEG frequency and human infrared frequency. The much higher frequency band of infrared as compared to EEG would translate to vast differences in information processing and storage capacity, discussed later in this chapter.

Table 2

Frequency Range: Brain Waves Versus Plasma Waves

Wave type	Frequency (Hz)
EEG “Brain Wave”	0.8–5 x 10^1 Hz
Infrared “Plasma Wave”	2.7–3 x 10^{13} Hz

Note. Data adapted from Nunez (2010), 216. Author’s table.

Using this date, potentially significant biological correlations can now be established. The human emission of radiation wavelengths in the 9.34 micron range not only lies within the infrared band, but is dimensionally the same size as a prokaryote, believed to have emerged as the first living organisms on planet Earth (Zimmer 2009, 667). This human electromagnetic wavelength of 9.34 microns also matches the average diameter of human blood capillaries at approximately 10 microns in diameter, the smallest of the body’s circulatory structures. It has been estimated that there are approximately 25,000 miles of capillaries within each adult human body (Romanes 1964, 840). To appreciate the significance of the correlation of the human infrared radiation wavelength and the inner diameter of the human capillary system, it is important to understand the concept of waveguides in communication engineering.

WAVEGUIDES AND PHYSIOLOGICAL NETWORKS

It was discovered late in the nineteenth century that circular metallic tubes or hollow metal ducts, similar to A/C ventilation ducts but much smaller, could be used to channel and guide either sound vibrations in the air, or electromagnetic energy in air or vacuum. These structures, known as waveguides, have been used for over a century, both commercially and in research, to channel and guide vibrating energy of specific limited frequency ranges. Without waveguides, vibrational energy fields are transmitted in all directions. From a point source, these fields may be visualized as magnetic lines—arrows emerging from a point at the center of an expanding sphere. The energy disperses outwardly, the magnetic vectored arrowheads pushing outward as an infinitely expanding sphere.

A waveguide, however, constrains the component of the wave-front of vibrating energy to one specific linear direction in parallel with the center of the waveguide. Thus the wave itself loses very little power while confined to propagating down the center of the waveguide, like a stream of water emerging from the pinprick of a large, taut, water balloon (Dorf 1997).

In the mid-twentieth century, scientists began to develop microwave devices for radar and high information, bi-directional communication. In general, the inner dimension (diameter) of the waveguide must be of the same order of magnitude as the wavelength being "guided." Electrical engineers during World War II developed radar technology by using metal waveguides to channel, modulate, and detect frequencies in the microwave band (Dorf 1997).

Contemporary data networks, similarly, are commonly channeled through optical waveguides using the properties of thin transparent fiber optic materials. High-speed network optical fibers currently used in the global Internet most commonly use a glass fiber with a core diameter of 8–10 microns to confine light to their core. These optical fibers have been designed for laser communication in the near infrared—the frequency band in which the carbon dioxide laser (CO_2 laser) emits coherent radiation. The CO_2 laser is one of the most widely used lasers due to its ability to reliably operate at the highest-power efficiency currently found among laser systems (Kachris, Christoforos, Bergman, and Tomkos 2012).

Perhaps it should not come as a surprise then that living human blood cells operate within the same infrared band as does our Internet data, and that the blood system is saturated with carbon dioxide gas. If conscious information processing in the human bio-system uses electromagnetic energy as a medium, then an enormous waveguide networks may be identified within the 25,000 mile human capillary system of each human body. Dimensional analysis, developed in the following section, would indicate the possibility of two systems of enclosed, tubular structures that might act as waveguides for bands of networked human electromagnetics.

A recent proposal by the University of California Los Angeles neuroscientist N. J. Woolf goes so far as to identify the site of memory storage in the locus of microtubule channels:

> Most contemporary models of consciousness posit synaptic activity as the primary basis of consciousness . . . .The view I propose is that the site of memory storage is not within the synapse, but in the sub-synaptic zone, in the microtubules of the dendrite shaft . . . the logic to this proposal is that the synapse is a channel transmitting information, much like a radio receiver . . . . In this analogy, the

receiving channel is the synapse or spine. (2006, 83–84)

Such waveguides might be a function of any one or several systems within the physiology of the human body, such as the blood capillary system, the microtubule system, or other structures as indicated in Figure 8.

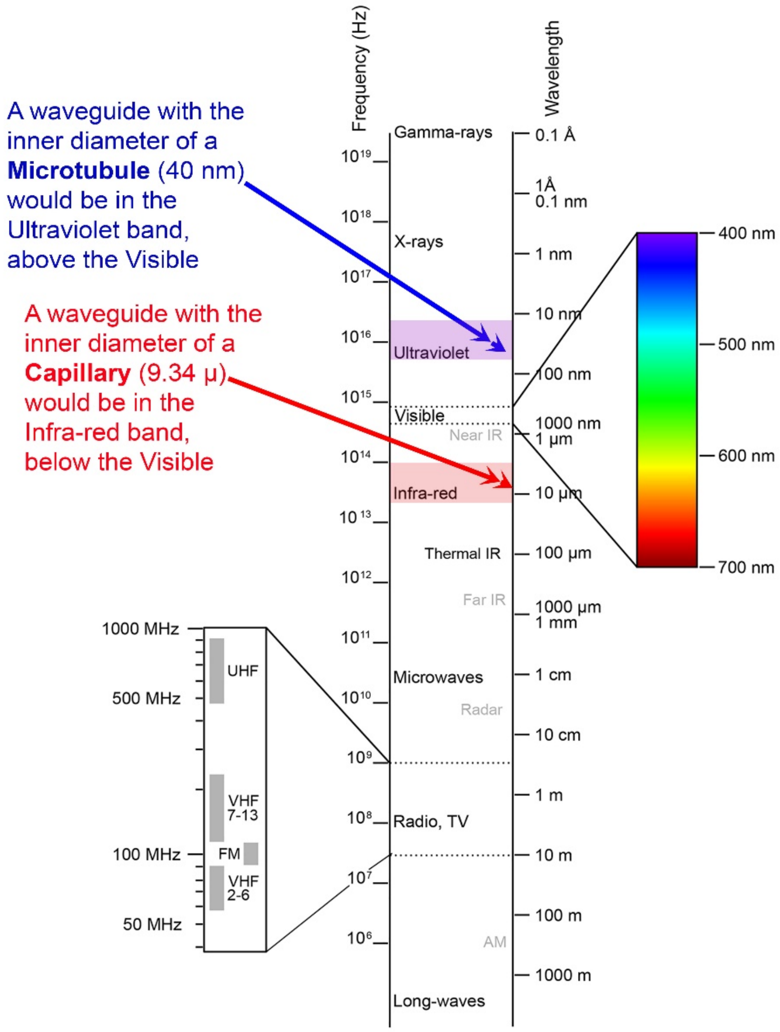

Figure 8. Microtubules and capillaries as waveguides. Annotations by author; graphic by Jahoe (2012). Reprinted under the terms of a Creative Commons Attribution ShareAlike 2.5 Generic license. Image retrieved from Wikimedia Commons.

BANDWIDTHS OF CONSCIOUSNESS

Dimensional evidence indicates that good candidate ranges for testing the electromagnetic field component of consciousness can be found in the infrared spectrum. This region lies just below the threshold of the visible spectrum that is detected and processed by eye cone structures (Oyster 1999).

Human body temperature ranges from a minimum of 68.0 F (hypothermia with loss of consciousness) to a maximum of 106.7 F (maximum core brain temperature before death). Applying Wien's Law to this range of human body temperature reveals the bandwidth of human electromagnetic wavelengths (Figure 9) to span the range from 9.88 to 9.11 microns, completely within the dimensions of human blood capillaries taken as waveguides.

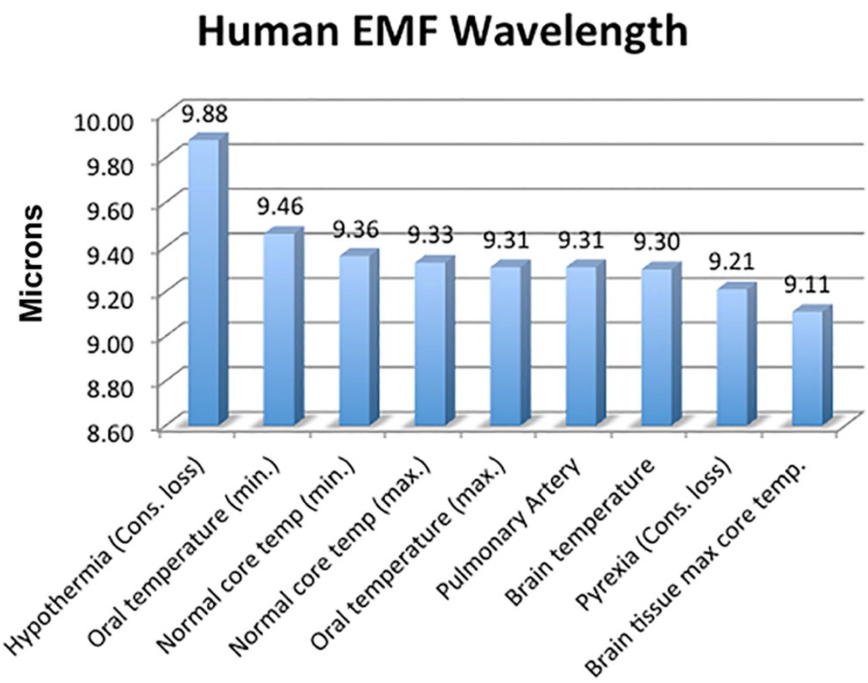

Figure 9. Human electromagnetic wavelength. Data from Geiger, Aron, and Todhunter (2003), 452. Graphic by author.

Converting from wavelength, this range is equivalent to a frequency range spanning from 30.3 Gigahertz to 32.0 Gigahertz, an enormously wide band compared to, for example, the FM radio frequency band used in the United States, which ranges from 87.5 to 108.0 Megahertz. This FM frequency band allows a maximum of 100 radio stations to be broadcast without overlapping signals. By comparison, the number of FM radio stations that could broadcast within the human infrared frequency band given in Figure 9 would be 8,500 with no overlapping interference from adjacent stations (Ruppert 1956).[2]

Assuming that electromagnetic energy within the infrared range is the vehicle of consciousness active within the human body, where might we search to detect such activity? One approach in the search for an infrared component of consciousness would be to monitor the dynamics of an infrared spectrum emanating from and external to the human body in an attempt to detect information laden photons escaping the body as modulated infrared radiation.

> Interestingly, because biologic materials are transparent to light in the near-infrared region of the light spectrum, transmission of photons through organs is possible. (Cohn 2007, 323)

Another approach would be to look for information modulation in infrared energy signals flowing as patterns within physiological waveguide channels throughout the human body. For example, the ubiquitous blood capillary system, with typical inner diameters of 10 microns, is a likely candidate to be acting as an electromagnetic waveguide. Capillaries provide a ready-made network infrastructure within which the flow and resonance of a modulated infrared energy plasma might be discovered.

CONCLUSIONS

In examining electromagnetic field radiation as a possible basis for consciousness we have examined several structural systems within human physiology that may involve consciousness as modulated electromagnetic energy; these have thus far been largely neglected in the widespread, possibly misdirected, assumption that brain structures and neurons are the only feasible biological structures involved with consciousness. While it is a widely held assumption that consciousness is an epiphenomenon generated through the action of neuronal spikes in the brain, we propose here that while the information/perceptual systems we call "mind" may operate in these systems, more fundamental qualia of consciousness may involve awareness tuning within the frequency domain at subquantum dimensions and ultra-high frequencies.

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[2] Calculations in this paragraph use Wien's Law to convert wavelength to frequency.

REFERENCES

Baggott, Jim. 2011. *The Quantum Story: A History in 40 Moments*. New York: Oxford University.

Becker, Robert O. 1990. *Cross Currents: The Perils of Electropollution and the Promise of Electromedicine*. New York: Jeremy Tarcher.

Becker, Robert O., and Gary Selden. 1985. *The Body Electric: Electromagnetism and the Foundation of Life*. New York: Harper.

Bell, Eric Temple. 1937. *Men of Mathematics*. New York: Simon and Schuster.

Benenson, Walter, John W. Harris, Horst Stocker, and Lutz Holger, eds. 2006. *Handbook of Physics*. New York: Springer Science.

Bohm, David. 1980. *Wholeness and the Implicate Order*. London: Routledge.

Clark, Walter. 1939. *Photography by Infrared—Its Principles and Applications*. New York: John Wiley & Sons.

Cohn, Stephen M., 2007. "Near-Infrared Spectroscopy: Potential Clinical Benefits in Surgery." *Journal of the American College of Surgeons* 205 (2): 322–32. doi: http://dx.doi.org/10.1016/j.jamcollsurg.2007.02.024

Cook, David M. 2002. *The Theory of the Electromagnetic Field*. Englewood Cliffs, NJ: Prentice-Hall.

Crease, Robert P. 2008. *The Great Equations: Breakthroughs in Science from Pythagoras to Heisenberg*. New York: W. W. Norton.

Darekk2. 2012. "File:Water_infrared_absorption_coefficient_large.gif" (graphic file). Wikimedia Commons. Retrieved from https://en.wikipedia.org/wiki/File:Water_infrared_absorption_coefficient_large.gif Dorf, Richard C., ed. 1997. *The Electrical Engineering Handbook*. 2nd ed. Boca Raton, FL: CRC Press.

Duff, Michael. 1996. "M-Theory (The Theory Formerly Known as Strings)." *International Journal of Modern Physics* 11 (32): 6523–41.

Feynman, Richard, Robert Leighton, and Matthew Sands. 1964. *The Feynman Lectures on Physics, Vol. 1*. Reading, MA: Addison-Wesley.

Geiger, Rudolf, Robert H. Aron, and Paul Todhunter. 2003. *The Climate Near the Ground*. Lanham, MD: Rowman and Littlefield.

Hertz, Heinrich. 1893. *Electric Waves: Being Researches On the Propagation of Electric Action with Finite Velocity Through Space*. London: MacMillan.

Jahoe. 2012. "File:Electromagnetic-Spectrum.png" (graphic file). Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Electromagnetic-Spectrum.png

Joye, Shelli R. 2016. *The Pribram–Bohm Holoflux Theory of Consciousness: An Integral

Interpretation of the Theories of Karl Pribram, David Bohm, and Pierre Teilhard de Chardin (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 1803306323).

Kachris, Christoforos, Keren Bergman, and Ioannis Tomkos. 2012. *Optical Interconnects for Future Data Center Networks*. New York. Springer.

Klein, Oskar. 1991. "From My Life of Physics." In *The Oskar Kelin Memorial Lectures*, edited by Gosta Ekspong, XX–YY. Singapore: World Scientific.

Lyon, Richard F. "File:Sine_wavelength.svg" (graphic file). Wikimedia Commons. Retrieved from https://commons.wikimedia.org/wiki/File:Sine_wavelength.svg

Mysid. 2008. "File:Atmospheric_electromagnetic_opacity.svg" (graphic file). Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Atmospheric_electromagnetic_opacity.svg

Nunez, Paul L. 2010. *Brain, Mind, and the Structure of Reality*. New York: Oxford University.

Oyster, Clyde W. 1999. *The Human Eye: Structure and Function*. Sunderland, MA: Sinauer Associates.

Pribram, Karl H. 1982. "What the Fuss is All About." In *The Holographic Paradigm and Other Paradoxes*, edited by Ken Wilber, 27–34. Boulder: Shambhala.

———. 2013. *The Form Within: My Point of View*. Westport, CT: Prospecta Press.

Romanes, George. J., ed. 1964. Cunningham's Textbook of Anatomy. 10th ed. New York: Oxford University.

Jones, Ron H. "File:CalabiYau5.jpg" (graphic file). Wikimedia Commons. Retrieved from https://commons.wikimedia.org/wiki/File:CalabiYau5.jpg

Ruppert, Oliver. 1956. *History of the International Electrotechnical Commission*. Geneva: Central Bureau of the IEC.

Tjlaxs. 2005. "File:YoungJamesClerkMaxwell.jpg" (graphic file). Wikimedia Commons. https://commons.wikimedia.org/wiki/File:YoungJamesClerkMaxwell.jpg

Warren, Stephen G., and Richard E. Brandt. 2008. "Optical Constants of Ice from the Ultraviolet to the Microwave: A Revised Compilation." *Journal of Geophysical Research*, 113 (D14): 1047–57.

Wilber, Ken, ed. 1982. *The Holographic Paradigm and Other Paradoxes: Exploring the Leading Edge of Science*. Boulder, CO: Shambhala.

Woolf, Nancy J. 2006. "Microtubules in the Cerebral Cortex: Role in Memory and Consciousness." In *The Emerging Physics of Consciousness*, edited by Jack A. Tuszyński, 49–94. New York: Springer-Verlag.

Yau, Shing-Tung, and Steve Nadis. 2010. *The Shape of Inner Space: String Theory and the*

Geometry of the Universe's Hidden Dimensions. New York: Basic Books.

Wilber, Ken, ed. 1982. *The Holographic Paradigm and Other Paradoxes: Exploring the Leading Edge of Science*. Boulder, CO: Shambhala.

Witten, Edward. 1995. "Some Comments on String Dynamics." *Strings: Future Perspectives in String Theory*. Princeton, NJ: Institute for Advanced Study.

Zimmer, C. 2009. "Origins: On The Origin of Eukaryotes." *Science* 325 (5941): 666–68.