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Astronomical, Chemical, and Biological Implications of 10^{-20} Joules as a Fundamental Quantum Unit of Information for Neurofunction

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The persistence of 10^{-20} J as the fundamental unit of interaction between the most fundamental electromagnetic and molecular interactions within physical-chemical and biological systems reflects a universal origin. This quantity becomes apparent when the energetic parameters associated with the future (final) epoch of the universe are applied at the level of the smallest length. The quantum is a primary solution for the Bohr frequency for specific electron shells and the integrative quantity between the action potential of the neuron and the bulk velocity of the entire cerebral electromagnetic field when applied to the equations for de Broglie waves and Heisenberg uncertainty. The continuous and serial transformation of the 10^{-20} J quanta within cellular and brain space could replace the myriad of molecular pathways to a single and fundamental operator. Because the difference between the energy equivalence for an electron's classic and Compton wavelength width by a Lorentz transform is about 10^{-20} J, this quantity, when applied appropriately, could facilitate the collapse of wave functions within brain space.

*Keywords:*Action Potentials; Bohr frequency; Genetic Vectors; Consciousness

1. Introduction

One of the alternative approaches to the myriad molecular pathways to explain information and function within the neuron is that the critical phenomenon is the transfer of a quantum of energy, ~ 10^{-20} J, through chains of physical-chemical processes. The primary correlate of thinking, the action potential of the neuron, involves a quantum amount derived from the effect of the net change in the potential ($1.2 \cdot 10^{-1}$ V) on a unit charge ($1.6 \cdot 10^{-19}$ A.s) or ~ $2.0 \cdot 10^{-20}$ J (1). This value is also the energy from applying the force ($1.8 \cdot 10^{-12}$ N) between the potassium (K^+) charges (~ 12 nm) over the membrane surface, the energy associated with the pressure (~ $5 \cdot 10^{-9}$ N/μm^2) from cohesion between cells within the volume occupied by atomic bonds, particularly covalent bonds, as well as the difference between phosphorylated (activated) and unphosphorylated subunits of compounds that compose enzymes and receptors. This critical unit emerges from the product of the voltage and current dipole found in dendrites divided by the velocity of delocalized electrons along DNA (1) and the energy associated with the second shell hydrogen bonds responsible for proton mobility in water (2).

The 10^{-20} J quantum is discretely associated with the release of photons from cell membranes (3) and is the energy equivalence of the wavelength calculated by Wein's law for a black body at biological temperatures, 310°K (36.85 °C). The astronomical implication of this quantum unit becomes evident when the threshold energy from gravitational force between any two K^+ ions that compose the single layer of approximately $2 \cdot 10^6$ ions associated with the resting membrane potential (1) is calculated. The gravitational force would be ($41.91 \cdot 10^{-52}$ kg^2) · ($1.44 \cdot 10^{-16}$ m^{-2}) ·G ($6.67 \cdot 10^{-11}$ m^3 kg^{-1} s^{-2}) or ~10^{-45} N. For 10^{-20} J to emerge, this force must be applied across a distance of ~ 10^{25} m, which is effectively in the order of the half-length of the universe as well as the Schwartzchild radius for a singularity assuming the universe's current mass.

The persistent occurrence of this quantum amount across biological and physical-chemical processes suggests a more central and cosmological origin and significance. From this context, the role of astronomical principles in the physical and chemical quantities of biological systems in particular and life in general becomes more prominent and explanatory. Quantifications of the contemporary and final boundary conditions of the universe support this possibility.

2. Cosmological Origin of 10^{-20} Joules

The significance of ~ 10^{-20} J as a fundamental quantum emerges when the volume of the universe for the bound-

Implication for health policy/practice/research/medical education:
This is an invited manuscript. The implication for health policy, practice, research, and medical education is reflected in showing the fundamental presence of the 10^{-20} J quantum across the basic components of neurophysiology. These same energetic units are found within the operation of the entire brain and are consistent with the sources from fundamental constants and units that define universal properties.

ary condition compared to the present time is accommodated. The current universe displays the following parameters: age: $4.2 \cdot 10^{17}$ seconds, r = $1.26 \cdot 10^{26}$ m, cross sectional area (πr^2) = $4.99 \cdot 10^{52}$ m^2, and volume = $8.38 \cdot 10^{78}$ m^3. The boundary condition (4) is derived from:

1) $G\rho$ (Newtonian G and mass density) where G is the Newtonian Gravitational Constant and density ρ=$1.67 \cdot 10^{-27}$ kg/m^3, which is one proton per cubic meter. The resulting squared frequency is equivalent to an age of $3.0 \cdot 10^{18}$ seconds (~ 90 billion years) and is within range of the fate (final epoch) of the universe according to the open cold matter (OCDM) model described by Hoffman et al. (5). The parameters for that final boundary are r = $8.99 \cdot 10^{26}$ m, cross sectional area = $2.54 \cdot 10^{54}$ m^2, and volume = $3.04 \cdot 10^{81}$ m^3. From the perspective of force, the total magnitude within the universe can be described in Newtonian form as the product of its mass, length, and square of the fundamental frequency. These values are m = $2.4 \cdot 10^{52}$ kg and length (2r), derived from the classical form (6):

2) $f = 8\pi G/c^2$, is $8.8 \cdot 10^{26}$ m and s^{-2} is the upper cut off for the zero point fluctuation ($3.23 \cdot 10^{43}$/s) or Zwitterbewegung (7), the square of which is $10.43 \cdot 10^{86} s^{-2}$. This results in a force of $2.20 \cdot 10^{166}$ N. If we assume there are Planck's length voxels (PLV) or spheres within three-dimensional space, then each voxel is $17.68 \cdot 10^{-105}$ m^3. This would mean that within the boundary volume of the final epoch, there would be $0.17 \cdot 10^{186}$ PLV within that universe. Divided into the total force, the quantity per PLV is $12.94 \cdot 10^{-20}$ N. When applied across the most fundamental wavelength of the universe, the neutral hydrogen line of 21.1 cm ($2.11 \cdot 10^{-1}$ m), the energy per PVL is ~ $2.7 \cdot 10^{-20}$ J. On the other hand if the current universal volume is employed the energy per PVL would be in the order of 10^{-17} J. Planck's Time in a dynamic process results in similar energy levels. When the estimated average magnetic field strength within and between galaxies is assumed, ~ 10^{-11} T (8), the application of the Eddington Number multiplied by the unit magnetic moment of the proton results in energy. Eddington's Number, derived from his model of primary degrees of freedom within expressions of states within the universe (2^{256}) multiplied by the fine structure value (137), is $1.59 \cdot 10^{79}$.

The simple product when multiplied by the mass of a proton ($1.67 \cdot 10^{-27}$ kg) and c^2 is $2.4 \cdot 10^{69}$ J. When Eddington's number is multiplied by the magnetic moment of a proton, $1.41 \cdot 10^{-26}$ $A \cdot m^2$ or J/T, and 10^{-11} T, the energy is $2.24 \cdot 10^{42}$ J. For the current energy of $2.2 \cdot 10^{69}$ J to occur as product of the current age of $4.2 \cdot 10^{17}$ s, the average magnetic field strength would be ~ $2.38 \cdot 10^{-12}$ T, which is still within the range of measurements and inferences. For comparison, both the calculated and measured average magnetic field strength associated with dynamic (cognitive) processes within the human cerebrum is ~ $2 \cdot 10^{-12}$ T.

The inclusion of unit time indicates that there would be, for the final epoch of 90 billion years, $3.0 \cdot 10^{18}$ seconds divided by $5.39 \cdot 10^{-44}$ seconds per Planck's Time, or $0.56 \cdot 10^{62}$ Planck's Time. The ratio for total energy per unit of final time is $4 \cdot 10^{-20}$ J. In other words, the energy associated with the magnetic moments of all of the protons applied to the universal averaged strength of its magnetic field by the time the universe approaches the final boundary is associated with 10^{-20} J per fundamental temporal unit.

3. Neurobiophysical Systems

The 10^{-20} J quantum relates multiple phenomena within the neuronal process that converts impinging electromagnetic energy to the transient action potential and through the primary inter-neuronal interface, the synapse. This quantum carrier of information can be considered the conservation of the 10^{-20} J generated by the electrostatic force between the potassium ions separated by about 10 nm and then applied over this distance. If 10^{-20} J is a critical quantum that relates biological processes to universal process, then its intrinsic properties should be reflected.

Although Planck's Length and Planck's Time are frequently involved with cosmological calculations that should involve gravitational phenomena, the relevance of Planck's Mass is sometimes considered marginal. The gravitational potential energy associated with Planck's mass can be estimated by:

3) $E = G\ (kg^2/m^{-1})$

If we assume the length is a fundamental value between 1 and 2 μm, which is the major range of the width of a synapse, the gravitational energy potential would be $(6.67 \cdot 10^{-11}\ m^3 \cdot kg^{-1} \cdot s^{-2}) \cdot (2.18 \cdot 10^{-8}\ kg)^2 \cdot (1 \text{ to } 2 \cdot 10^{-6}\ m)$ or between 1.5 and $3.1 \cdot 10^{-20}$ J. However, the relationship becomes convergent as Bohr's estimates for the quantum involved when one (hydrogen) nucleus is removed from another is considered. The frequency is:

4) $v_r = 1.32\ \acute{\omega}o\ \sqrt{m/M}$

where $\acute{\omega}o$ is the inverse of the time for one orbit ($6.2 \cdot 10^{15}$ Hz) around a Bohr magneton, m is the mass of an electron and M is the mass of the proton. The solution for v_r is $1.91 \cdot 10^{14}$ Hz or λ_r = 1.57 μm. This frequency, which is within the near infrared spectrum, is the same order of magnitude as that estimated for the atomic (nuclear) vibration of hydrogen on the basis of heat. When this value is employed as the distance in the equation, the gravitational potential energy for Planck's mass is $2.02 \cdot 10^{-20}$ J.

4. Consciousness and Cerebral Cortical Electromagnetic Fields

The A vector, one of the recondite components of electromagnetic fields, contains intrinsic properties that are considered "not manifested" or not apparent, in a tradition very similar to Eddington's (9) modes "non-existence" or "dormant particles". As opposed to the perpendicular orientation to the electrical field, the A vector moves along the same direction as the current. The essential dimensional analyses of the A vector is: $\{[kg^2 \cdot (As)] \cdot [kg \cdot (As^2)]^{-1}\}$. If this is applied to an electron's

classical mass of $9.11 \cdot 10^{-31}$ kg and unit charge ($1.6 \cdot 10^{-19}$ As) within the average magnetic field strength associated with enhanced cerebral activity ($3 \cdot 10^{-12}$ T), the solution is $17.29 \cdot 10^{-31}$ kg $\cdot s^{-1}$. To obtain momentum within this system multiplication by λe of the electron ($2.82 \cdot 10^{-15}$ m) and the square of the Bohr frequency ($6.58 \cdot 10^{15} \cdot s^{-2}$) results in $2.11 \cdot 10^{-13}$ kg $\cdot$ m $\cdot s^{-1}$. When applied across the plasma membrane (10^{-8} m) at the frequency with the peak spectral power density within the cerebrum (10 Hz), the value is $\sim 2 \cdot 10^{-20}$ J.

The importance of fundamental matter in both consciousness and the quantum of 10^{-20} J was evident in de Broglie's matter wave metaphors during the early development of quantum theory. These waves depended upon the quantity of momentum which was $h \cdot \lambda^{-1}$ where h was Planck's constant ($6.626 \cdot 10^{-34}$ J $\cdot$s) and λ is wavelength. The resulting dimensions are kg m^{-1} s^{-1}. For the proton or electron (classical) with a radius or wavelength of $2.8 \cdot 10^{-15}$ m, the value is $2.35 \cdot 10^{-19}$ m $\cdot s^{-1}$. However, if the packet was moving at an average of 4.5 m $\cdot s^{-1}$ ($\Delta t \sim 25$ ms) associated with rostral-caudal bulk velocity within the cerebral cortices, the energy would be 10^{-20} J. Similarly, one variant of the Heisenberg Uncertainty principle is:

5) $\delta_p \delta_x > h$

where δ_p is the change in momentum, δ_x is the uncertainty of the location, and h is Planck's constant. If the complete certainty of the location of an electron with a classical radius ($2.82 \cdot 10^{-15}$ m) is assumed, then the difference (uncertainty) of momentum is $2.35 \cdot 10^{-19}$ kg $\cdot$ m $\cdot s^{-1}$. Assuming a bulk velocity of 4.5 m $\cdot s^{-1}$ for the physical substrates that generate the ~ 40 Hz phase shifts, the transcerebral fields would be represented by a value of $\sim 10^{-20}$ J (10). Perhaps the most relevant potential role of 10^{-20} J in the role of consciousness involves the transformation of an electron's energy from mass equivalents to wave. The collapse of the quantum wave is considered to the process by which human consciousness and many other biological phenomena occur. As shown previously the relativistic compression described by the Lorentz transform to accommodate the difference between the Compton wavelength of an electron ($2.4 \cdot 10^{-12}$ m) and the classical width of the particle form ($2.82 \cdot 10^{-15}$ m) requires a velocity approximately 0.9999995 c (11). The difference between the energy equivalence for the electron moving at c versus this modified velocity is equivalent to an energy difference of 10^{-20} J.

In other words, the "collapse" of the wave function would be associated with the equivalence of the energy associated with the single action potential of the neuron. The burst spiking activity of one cortical neuron has been shown experimentally to shift the global brain state (12). The collapse of this function, often localized within the spatial domain of the microtubules and manifested as "beat frequencies" from faster molecular vibrations, has been considered the primary correlate of the Hameroff-Penrose description of consciousness (13). The energy required for such conformational changes in the composite structures of microtubules is in the order of 10^{-20} J. This is in the same range as the force (~ 2 pN) to stretch DNA to 90% of its contour length (14), which when applied across the width of a plasma membrane (10^{-8} m) is equivalent to about 10^{-20} J.

5. Temporal Persistence

The similar magnitudes of magnetic field strengths associated with the cerebral activity correlated with cognition as well as consciousness and intergalactic field strengths may have significant implications with respect to the temporal persistence or "immortality" of at least a subset of the processes. This can be inferred from the induced magnetic moment that corresponds to the change in angular velocity traditionally described as:

6) $\Delta m = -[e^2 r^2 (4 m_e)^{-1}] B$

where e = unit charge ($1.6 \cdot 10^{-19}$ As), r = the Bohr radius ($5.29 \cdot 10^{-11}$ m), m_e is the mass of an electron ($9.11 \cdot 10^{-31}$ kg), and B is the magnetic field strength of the cerebral dynamics ($2 \cdot 10^{-12}$ T). The result is a very weak change in magnetic moment of $3.9 \cdot 10^{-41}$ A $\cdot m^2$ or J/T. Because this cerebral field is also immersed within the interstellar magnetic field strength within galaxies, which is $\sim 10^{-10}$ T (8), the resulting energy would be in the order of 10^{-51} J. From a quantum perspective, this extremely small quantity can still be related by dividing it into Planck's constant. The time is $\sim 10^{17}$ s, which is within the range as the age of the universe. In order for the duration of this process to extend to the final epoch ($3 \cdot 0 \cdot 10^{18}$ s (4, 5)), the net energy must be $2.2 \cdot 10^{-52}$ J, which is within the coefficient and boundary for the upper limit of the rest mass of a photon as c^2 approaches unity (15). Within the estimated $2.4 \cdot 10^{-12}$ intergalactic average field (section 2), the energy converges with the value of 10^{-52} J.

6. Conclusions

The concept of the fundamental unit of matter has shifted from the monad of Leibnitz to the proton (or electron) of contemporary physics. There may also be a fundamental unit or quantum of energy that permeates the multiple structures of sub-matter ($< \sim 10^{-15}$ m) space as well as the material that constitutes living systems. The first order approximation for that unit is $\sim 10^{-20}$ J. This quantum represents the energy associated with the action potential of the neuron and emerges as a primary quantity for the whole cerebrum, suggesting the conditions of a hologram. the energy equivalence of an electron moving at the velocities required to produce the discrepancy between the classical and Compton radius is $\sim 10^{-20}$ J; it suggests that the phenomena strongly correlated with neuronal activity, such as observation (perception) and cognition, have the capacity to "collapse" the wave function of the energy-mass relationships. The requirement for the gravitational force between charged ions that contribute to the action potential to be extended over a distance that is the width of the universe to obtain this

value, indicates the collapse of the wave function could occur anywhere within that volume.

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Authors' Contribution

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