Brain's Neuronal-Planck's Constant

Moninder Singh Modgil*

Spiritual Applications Research Center (SpARC)
Gyansarovar, Mount Abu, Rajasthan, Pin 307501
India

ORCID: 0000-0002-1890-2841

ABSTRACT. We introduce following four Ansatz – (1) That the human brain, can be regarded as a set of 100 billion quantum mechanical oscillators – with each oscillator, representing a Neuron. (2) The oscillator's frequency ν corresponds to the Neuron's firing frequency. (3) The amplitude A, represents the amount of neurotransmitters released at the synapse via vesicles. (4) Neuron-Quantum-Mechanical-Energy (NQME), of each oscillator/neuron is defined as analogous to the case of photons. We calculate the order of magnitude of the Brain's Neuronal-Planck's Constant (BNPC) h_{Neuron} which is $10^{-16}\, Joule - Seconds$. Excitation level of neurons, are calculated for various brain regions.

I. INTRODUCTION.

Here in, we model the brain as a set of 100 billion quantum mechanical oscillators. We extend the formula $E = h\nu$ of photons to brain's neurons -

$$E_i^B(t) = h_{Neuron}\nu_i(t) \qquad (1)$$

where, h_{Neuron} is Brain's Neuronal-Planck's Constant (BNPC), and $E_i^B(t)$ is the Energy of the i^{th} neuron, with a firing frequency $\nu_i(t)$ – where t represents Time. The superscript B refers to Brain, within this paper.

We calculate the excitation levels of different brain regions, using the formula –

$$E_i^B(t) = \left(n + \tfrac{1}{2}\right) h_{Neuron}\nu_i(t) \qquad (2)$$

We now briefly give a back ground, of the early work on Quantum Mechanics in the Brain. Sir John Carew Eccles, a renowned neurophysiologist, was deeply interested in the relationship between the brain and the quantum mechanics. Eccles drew upon quantum mechanics, particularly the uncertainty principles, as a way to explain how mental intentions could influence physical brain processes. The uncertainty principles leave room for non-physical influences to affect the outcome of physical processes. He collaborated with physicist Friedrich Beck to develop a model in which quantum uncertainty at synapses (the connections between neurons) allowed for the observer's decisions to affect neural processes without violating physical laws [1]. Eccles dualistic view is expressed in a book coauthored with Karl Popper [2].

II. CALCULATION OF BRAIN"S NEURONAL PLANCK"S CONSTANT, NAMELY h_{Neuron}

Let the number of neurons in brain be N . We let the index i run over all the neurons in the brain (Central Nervous System to be more precise, including spinal cord, nerves, various sensors cells including those of retina).. Let $\nu_i(t_m, t_n)$, be the firing frequency of neuron n_i, during the time interval (t_m, t_n). Define average firing frequency of neurons as,

$$\nu^{Av} = \frac{1}{N}\sum_{i=1}^{N}\nu_i \sim 10^3 \qquad (3)$$

Conscious Power consumed by the neuron over the time interval (t_m, t_n) is,

$$P_i = \frac{E_i(t)}{\Delta t} \qquad (4)$$

$$\Delta t \sim 10^{-3}\, Seconds \sim \frac{1}{\nu^{Av}} \qquad (5)$$

Now, the total power consumption of the brain P^B is,

$$P^B(t_m, t_n) = \sum_{i=1}^{N} P_i(t_m, t_n) \qquad (6)$$

We can take brain's power consumption as,

$$P^B \cong 20\, Watts \qquad (7)$$

Taking $N \sim 10^{11}$, we have

$$P^B = \frac{h_{Neuron}\nu^{Av}}{\Delta t} \qquad (8)$$

which gives the desired value of Brain's Neuronal Planck's constant as -

$$h_{Neuron} \sim 10^{-16}\ Joule - Seconds \quad (9)$$

Compare this mesoscopic Brain's constant with the value of the microscopic Planck's constant of quantum mechanics,

$$h \sim 10^{-34}\, Joule - Seconds \qquad (10)$$

A difference of 18 orders of magnitude! We will refer to h_{Neuron} , as the Brain's Neuronal-Planck's Constant (BNPC).

III. CALCULATION OF EXCITATION LEVELS OF VARIOUS BRAIN REGIONS

Consinder the eq. (1) using which, we can calculate the average energy of various brain regions – taking the known average EEG frequency. Consider the eq. (2) using which we can calculate excitation levels n of neurons in the different brain regions. The results of these calculations are given in Table 1.

TABLE I. The calculation of the Energy and the excitation level n, of the various brain regions.

S. No.	Brain Region	EEG Frequency ν (Hz)	Energy (J) $\times 10^{-16}$ From eq (1)	Excitation Level n From eq (2)
1	Limbic System	4 Hz	88.1	25
2	Cerebellum	13 Hz	34.7	11
3	Hypothalamus	4 Hz	40.6	25
4	Hippocampus	4 Hz	88.1	25
5	Reticular System	1 Hz	14	2
6	Amygdala	4 Hz	88.1	25
7	Midbrain	10 Hz	15.1	3
8	Medulla Oblongata	1 Hz	14	2
9	Brain Stem	1 Hz	14	2
10	Spinal Cord	1 Hz	5	6
11	Corpus Callosum	10 Hz	25	6
12	Occipital Cortex	10 Hz	33	4
13	Motor Cortex	20 Hz	24	7
14	Sensory Cortex	20 Hz	24	7
15	Frontal Cortex	40 Hz	12	2
16	Prefrontal Cortex	80 Hz	7	3
17	Temporal Cortex	60 Hz	9.9	5

IV. Conclusions

Are we living in a Quantum Mechanical Hilbert Space – rather than in the Space-Time of Special and General Relativity? As Francis Crick [3] says in his book "The Astonishing Hypothesis", that our thoughts and perception, are due to the neuronal processes within the brain. Given that, it follows that our perception of the 3 dimensional space, and the psychological experience of flow of the time, are also brain constructs. Extensions to Special and General Theories of Relativity, existence of particles and fields - are again mental constructs.

Eddington [4] expressed skepticism about the fundamental nature of particles like electrons. Eddington was known for his philosophical approach to science and often discussed how our understanding of particles is based on models and theories rather than direct, concrete knowledge of what those particles "are" in a physical sense. The more precise form of this sentiment can be linked to his idea that scientific models are not necessarily literal descriptions of reality but rather tools we use to understand and predict natural phenomena. Eddington, along with other scientists and philosophers of science, argued that what we call "electrons" or other subatomic particles are essentially constructs of our scientific theories, which help us explain experimental observations.

. Another similar viewpoint can be attributed to Niels Bohr [5], who was instrumental in the development of quantum theory. He often expressed that particles like electrons are not objectively "real" in the classical sense but are better understood in terms of their interactions and measurements as described by quantum mechanics.

The sentiment also aligns with Werner Heisenberg [6], who in his writings emphasized that atomic particles do not have the same tangible, independent existence as macroscopic objects and that our descriptions are fundamentally linked to the theories and experiments we use.

The "Observer cum Participator" as said by Wigner [7], therefore, interacts Quantum Mechanically with the Quantum Brain – and so must be a Quantum Mechanical Entity itself.

Wheeler [8] extended this view with his idea of the *Participatory Universe*, suggesting that the very act of measurement brings things like electrons into existence. He famously said, "No phenomenon is a real phenomenon until it is an observed phenomenon."

Given the conceptual difficulty of integrating the Quantum Mechanics with the General Theory of Relativity [9]– and quantum mechanical functioning of all physical systems – we are led to the conclusion that the theories of the physics, not involving direct human perceptions – are based upon, the various macroscopic amplifying devices (instruments), which inform the brain about the microscopic world, as well as the secrets of the cosmos. These are thus, deductions, based upon the Quantum Mechanical processes with in the brain.

Following von Neuman's approach to quantum measurement [10], we have proposed the Ansatz [11], that one of the properties of observer, is that it's a Dirac Delta Function, due to its properties of localization and singular nature. Indeed, our visual perceptual experience places us at the origin of a 3-dimensional coordinate system.

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