Editor's Note

Is Quantum Physics Necessary to Understanding Consciousness?

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Over the past ten years, discussions of the roles that quantum mechanics might or might not play in the theory of consciousness have become increasingly sharp. One side of this debate stand conventional neuroscientists who assert that brain science must look to the neuron for understanding, and on the other side are certain physicists, suggesting that the rules of quantum theory might influence the dynamics of mind.

Despite ever increasing knowledge of brain activities related to cognition, the mystery of consciousness experience looms deeper than ever. Consciousness has been assumed to be a mystery which had been withdrawn from the scientific investigation of modern behaviorism. Consciousness was placed exterior to the matter. Consciousness, thus banished from the realm of modern science, has been taken into serious account almost exclusively in philosophy, epistemology, and the mystical aspect of theology. The key element for the still missing bridge between consciousness and matter.

The end of the 19th century has seen physics, what we term now "classical physics", as a monumental construction, which, according to some of its founders such as Lord Kelvin, Poincare and other prominent figures was bound to be the "ultimate explanation of nature" the "frame of the system of the world". Physical reality was conceived as the interplay of two basic entities, particles of matter and fields of forces. Matter was conceived as separable into independent particles. The bridge between the molecular model and the psycho-emotional model of humans and, more general living organisms is still missing.

However, consciousness and mind are not separate from matter. Submicroscopic world of the human brain give rise to consciousness, mind. Matter is made up of many atoms in which electrons are in energy eigenstates. Each electron in each energy states is understood to have energy equal to the corresponding energy eigenvalue. However, we are never able to

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make a sharp separation between mind and matter. Thus ultimately there is no "mind" that can be separated from "matter" and no "matter" that can be separated from "mind".

The brain as a mixed physical system composed of the macroscopic neuron system and an additional microscopic system. The former consists of pathway conduction of neural impulses. The latter is assumed to be a quantum mechanical many-body system interacting with the macroscopic neuron system. The behavior of any single neurons should not be significant for the functioning of the whole brain. The neurons do not seem to be the only fundamental units of the brain, together with them some other elements may play important role. There are to envision two different kind of levels of physical activity in the brain, one of them classically describable, while the other one needs to described in quantum theoretical way. A typical state of brain then includes both levels. Brain and neurons, being material, has at some scale a quantum physical composition. Quantum physic is the correct framework for exploring the world of atoms and molecules.

Quantum theory along with the theory of general relativity is one of the main pillars of physics and our scientific worldview. Within the history of science, no other theory has been precisely confirmed experimentally. Many quantum physicists have in fact proposed that there are strong resemblances between quantum theory and consciousness. Such analogies were proposed to exist early on by the "founding fathers" of quantum theory and neuroscience. Among them are David Bohm (1951), Niels Bohr (1958), von Neumann (1955), John Eccles (1986), Roger Penrose (1989 and 1994), Henry Stapp (1993). The traditional mind/brain problem then becomes the "quantum mind/classical brain" problem.Their common and principal interest has been in the acausal and non-local character of the wavefunction frequently discussed in the problem of quantum measurement.

There are by now a number of different and much more detailed suggestions about where such "quantum sites" (synapse, microtubules, membrane proteins etc...) could be located in the brain or neuron.

We would expect therefore that this should be equally true for any attempt to gain an understanding of the emergence of mind from matter. This topic would appear to be a promising field for future research at the present time. There is a possibility of a revolution in our understanding of the mind that might parallel the significance of the quantum revolution in physics. I suggest that quantum analogies can enrich both our introspective experience of the mind and theories we construct in psychology. Many scientist studying consciousness consider that the evidence and theory currently have to be developed in a sustained way, and a firmer understanding of consciousness is now being accelerated by new evidence from cognitive neuroscience, neurophilosophy, neuropsychology and "new physics", i.e., *NeuroQuantology*.

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