Quantum Reality and Consciousness

Gary Venter

One way to think of quantum mechanics is purely as formulas for calculations and predictions. Quantum reality takes the opposite view: the objects in the formulas are real. For them to do what the formulas say would put them outside of the previous paradigm of physicality. From there, also including consciousness in physical reality would be a small additional step that would support quantum-neurological modeling of conscious experience.

Quantum reality does not require mathematical reality – the view that mathematical objects (sets, etc.) are real, and theorems are facts about reality. Quantum mechanics, like other wave models, postulates a mathematical object, the wavefunction, whose movements follow a wave equation. The electromagnetic wavefunction, for instance, is regarded as a real object that behaves according to its wave equation. Quantum realists hold that the quantum wavefunction is like that. It replaces wave-particle duality – which historically was not viewed as reality either, but as two modes of description. But then collapse theory postulated that quantum wavefunctions become real particles when a measurement is observed. This involves consciousness, which is not part of the quantum system and is not explained. Quantum realists reject collapse theory and have built up a degree of skepticism about invoking consciousness in quantum matters.

The realist view, per Carroll (2019):

- "Atoms aren't mostly empty space; they are described by wavefunctions that stretch throughout the extent of the atom."
- "Quantum mechanics ultimately unified particles and fields into a single entity, the wavefunction."
- "Quantum reality is a wavefunction."

In classical physics the context determines whether the mathematical function or the physical wave is being referenced, but to be careful here, call the wavefunction the mathematical entity and the wave it describes a "function wave." This is a new type of wave. Function waves are not energy waves and don't work by applying forces but through functional influence. Two highly correlated function waves, perhaps far apart, can change everywhere instantly from the measurement of one part. Relativity limits propagation of force waves to the speed of light, but not function waves. There is no rapid movement of forces and no action at a distance.

Classically, energy waves propagate in force fields, like the electromagnetic field. That takes values in its state space, a two-dimensional Euclidean space. The pair (e,m) gives the strength of the electric and magnetic components. The state space for wavefunctions in basic quantum mechanics is a two-dimensional space called the complex plane, with axes labeled real and imaginary. The pair (a,b) is usually written a+bi, where b is the value on the imaginary axis. Each of these state spaces is a Hilbert space - basically a space with a distance function. Quantum field theory uses a more complicated Hilbert space. Having these alternative state spaces is not a big step in moving to quantum reality, as state spaces are not regarded as part of the real universe. The big step is accepting the physical reality of function waves that do not carry forces. Like electromagnetic waves, they would exist in space and their influences would be observed.

Consider a wavefunction for the location of an electron. At (x,y,z,t,a+bi), the modulus of the wave, $\sqrt{a^2 + b^2}$, gives the probability that the electron is at (x,y,z,t). If the electron shrinks into a much smaller region through measurement, its resulting location is random but is guided by its probability distribution. This can be verified by repeated measurement of like waves. In practice, the probabilities can also be treated as the distribution of the charge and mass of the electron over space-time.

The modulus is not affected by positive vs. negative or real vs. imaginary distinctions. E.g., -b + ai would have the same modulus. But those distinctions affect the movement of function waves according to the Schrödinger wave equation. The probability distributions of mass and charge of electrons is not enough to predict their future behavior. That needs the whole wavefunction in quantum space. There is no Schrödinger force that enforces this behavior – it is functional influence, not cause and effect from the application of forces.

Electrons in an atom are portrayed in orbital shells, which are usually ellipsoids around the nucleus. The electron function waves are standing waves in set positions throughout the atom. The wavefunction is constrained by the charges of the electrons and protons. With those constraints, the orbitals are surfaces of maximal modulus values. The wavefunction is not zero off of those surfaces: some probability is located in-between them. The atom can be described as having a cloud of electrons, where the density of the cloud is highest on the orbitals.

There is a region near the nucleus where the wave equation makes the probability zero. That is what prevents electrons from collapsing into the nucleus from electrical attraction. There is no force operating to oppose the attraction - the probability being zero is what keeps atoms from annihilation. Non-causal influence from function waves is critical to maintaining the existence of atoms. That is part of the motivation for considering them to be real, physical things.

Another consequence of the wave equation is the Pauli exclusion principle: like particles cannot be in the same place. This keeps atoms from interpenetrating. There is no Pauli force that carries it out. Thus the hardness of matter is due to functional determinism as well. The world as we know it is created by functional effects not intermediated by forces.

Specifying the nature of function waves is an open question in quantum realism. They are not mathematical but are not traditionally material either. Mental states as experienced have those characteristics. Postulating a mental aspect for function waves would begin to specify a nature for them and would also create research paths for modeling conscious experience in neural networks.

We now know that conscious experience is an emergent property of neural networks. But that does not yet explain what creates the consciousness. Dehaene and Changeux (2011) summarize studies on the Global Neuronal Workspace (GNW) model "according to which conscious access occurs when incoming information is made globally available to multiple brain systems through a network of neurons with long-range axons densely distributed in prefrontal, parieto-temporal, and cingulate cortices." A signal is greatly amplified "in a cascading manner, quickly leading the whole stimulus-relevant network into a global self-sustained reverberating or 'ignited' state." This is "flexibly shared by many cortical processors." GNW identifies necessary and sufficient conditions for conscious experience, as indicated by subjects' reports. Massively parallel replication of a signal holistically across multiple brain regions can amplify whatever conscious potential the signal may contain, elevating it above lower-level background static.

Emergent properties arise from behavior of components. E.g., the group behavior of bird flocks, which move like single entities, comes from two individual-bird traits: a strong tendency to follow others and a weak tendency to deviate. When a bird deviates, it is often not followed, but when it is, the whole flock can turn. Such an explanatory mechanism has not been found for emergence of consciousness in neural networks. The pieces all work together and seem to produce conscious experience, but how they manage to do that is not explained. An implementing ingredient seems to be missing. Research is planned to find out more detail about types of neurons, their roles, and connections, but lacks a program for finding explanatory mechanisms. Quantum-neurology incorporating consciousness within wavefunctions could provide the needed mechanism.

Fisher (2015) identifies a phosphorus molecule that can maintain quantum qubits in living systems. If they last long enough, the brain could be a huge quantum computer. Player and Hore (2018) detail reasons why these qubits can last just a few seconds, which isn't enough for Fisher's goals. Still, it is long enough for brain events. Fisher (2016) notes that he began looking for neural quantum effects when he learned that two chemically virtually identical isotopes of lithium that differ in quantum potential affect murine behavior quite differently.

The physical nature of the quantum field is unknown. The modulus gives the probabilities, but the individual influences of real, imaginary, positive, and negative components are unspecified. There is a lot going on in the quantum wavefunctions that does not show up in the probabilities. Something other than the modulus could quantify awareness as an input feature for neuronal processes. Pure awareness could be an aspect of the quantum field but would not necessarily entail a subject of experience. The logic of "x Experiences ⇒ x Exists" has been challenged. E.g., Strawson (1967) holds that that expression is not well-formed as existence is not a predicate.

A measure similar to the modulus could be simply that $|b|$ gives the level of awareness, i.e, consciousness is imaginary. That's one of many possible quantifications. Pradhan (2012) suggests that consciousness is measured by the complex conjugate of the wave value, $a - bi$.

It is reasonable to hold that the laws of quantum mechanics are purely descriptive, as they characterize processes that are not the causal action of forces. Yet wavefunctions have such key roles in the existence and behavior of the physical universe that they are compellingly at least as real as anything else. The nature of the waves is unknown but is not traditionally material. It is not a major further step to take them as incorporating consciousness. The advantage is that would open up avenues for quantum-neurological modeling of conscious experiences, bringing modeling of consciousness into physics. Mental and neurological processes would come from the quantum field in a coherent manner, neither controlling the other.

References

Carroll, Sean. 2019. "Something Deeply Hidden." Dutton.

Dehaene, Stanislas, and Jean-Pierre Changeux. 2011. "Experimental and Theoretical Approaches to Conscious Processing." Neuron 70: 200–227.

Fisher, Matthew P.A. 2015. “Quantum Cognition: The Possibility of Processing with Nuclear Spins in the Brain.” Annals of Physics 362: 593–602.

Fisher, Matthew P.A. 2016. “Quantum Cognition - Theory and Experiment.” FQXi Conference, Banff. https://www.youtube.com/watch?v=ntwHETz84Cw .

Player, Thomas C. and P. J. Hore. 2018. “Posner qubits: spin dynamics of entangled Ca9(PO4)6 molecules and their role in neural processing.” Journal of the Royal Society 15 – 147.

Pradhan, Rabindra K. 2012. “Psychophysical interpretation of quantum theory.” NeuroQuantology 10-4: 629-645.

Strawson, Peter Fredrick. 1967. “Is Existence Never a Predicate?” Critica: Revista Hispanoamericana de Filosofia 1-1.