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Beyond the Stalemate: Mind and Body, Interview with Stuart Kauffman
Ryan Cochrane

Ryan Cochrane (RC): Since the 17th Century and Newton, we have been locked into Reductive Materialism. What are the implications for the Mind-Body problem?

Stu Kauffman (SK): It all starts with Descartes in 1640, who proposed his famous Dualism, *Res Extensa*, the mechanical worldview, and *Res Cogitans* or thinking stuff, a substance dualism. But with Newton, *Res Extensa* won and we have since then lost the subjective pole of, "cogitans", conscious experience. *Res extensa* matured with Newton; Newton invented classical physics, differential and integral calculus, three laws of motion and universal gravitation. Imagine six billiard balls rolling on a billiard table. What will happen to the balls? Newton told us to write down the initial conditions of all the balls, that is their positions and momenta, and the boundary conditions of the edges of the table, and his laws in differential equation form giving the forces between the billiard balls. Then to find out how the balls will move, we are to integrate his differential equations to derive the trajectories of the balls moving on the table. But integration is deduction of the consequences of the differential equations for those deterministic trajectories.

Then the Mind-Body problem in classical physics is this: If the brain is a classical physical system, then the current state of the brain plus possible classical inputs, is entirely sufficient to causally determine the next state of the brain. But then there is "Nothing for mind to do. Worse, there is no way for mind to do it". Thus, if the brain is classical physics and if we are conscious at all, that consciousness can have no effects on the becoming of the world or ourselves, and is merely "epiphenomenal." More we have no free will.

This is the stalemate of the mind-body problem. The stalemate arises from the causal closure of classical physics. If we demand that "mind" act causally on the meat of the brain, again, there is nothing for mind to do, and no way to do it.

RC: How does quantum mechanics take us beyond classical physics and can it help with the mind-brain problem?

SK: The fundamental reason Quantum Mechanics can get us beyond the stalemate is that in two different ways quantum mechanics can have acasual consequences for the "classical world" therefore "quantum mind" can have acausal consequences for the meat of the brain. The acausal consequences break the casual closure of classical physics.

We need to think about some of the basics of quantum mechanics.

It's useful to start with the famous two-slit experiment which consists in a photo-gun that shines photons at a screen with two-slits in it. Beyond the screen is a film emulsion. Cover the left slit with a piece of cardboard, shine the photons through the screen where photons pass through the open right slit and arrives at the film emulsion. Later develop the film emulsion. You will find a bright spot beyond the right slit on the film. Now uncover the left slit and cover the right slit and repeat the experiment. After you develop the film you will find a bright spot behind the open left slit. But, dramatically, if you open both slits, and repeat the experiment, after you develop the film you will find a set of alternating bright and dark bands spread out between the places on the film between the places of the bright spots seen when only the left or right slit was open.

If you shoot one photon an hour through two open slips you still get the same interference pattern. As famous physicist Richard Feynman said "There is no way to explain this interference pattern with classical particles." To explain these and other astonishing results Schrodinger invented the famous Schrodinger equation, a linear wave equation with no energy associated, so what is waving is not "stuff" in the sense of matter and/or energy.

The spot on the developed film emulation is from a single photon in the interference pattern. A single spot from a single photon found on a developed film emulsion is an example of quantum measurement. The Schrodinger Linear Wave Equation is slightly analogous to a set of waves of water passing through a sea wall with two gaps towards a beach. For a train of waves propagating towards the beach as each wave passes through the two gaps, two concentric semicircular waves will propagate towards the beach. Now think of a set of such semicircular waves arising from a set of parallel water waves hitting the gaps in the sea wall, and arriving at the beach. If one walks along the beach there will be places where crests from the left gap and from the right gap both arrive to form a higher crest. There will be places on the beach where two wave valleys both arrive creating a lower valley. There will also be places where the crest of one wave meets the valley of the other and the two waves annihilate each other. The higher crests and lower valleys correspond to the light bands in the interference pattern. Where the crests of one wave arrive with the valley of another wave so they will cancel each other out, corresponds to the dark bands in the interference pattern.

In Quantum Mechanics one can think of the "wave-like" behavior prior to quantum measurement and particle like behavior when the spot occurs at quantum measurement. This is the wave particle duality. It is essential to point out that quantum measurement is acausal. On the Copenhagen interpretation of Quantum Mechanics, the result of measurement is the classical world.

There is a second acausal way in quantum mechanics that the quantum world can have acausal consequences for the "classical world". The way is called "decoherence". In the Schrodinger wave equation, the "phase" of the wave is known at each point in time and space, via an action variable. In an open quantum system, this phase information can be acausally lost to the remaining universe. This acasual loss of information is decoherence. As decoherence proceeds, the interference pattern fades and we are left with two bright spots on the developed film emulation behind the two slits. Physics say decoherence approached the classical world arbitrarily closely.

RC: So how does acasual quantum measurement and acausual decoherence approaching the classical world arbitrarily closely with the help of the mind-body problem?

SK: I need to tell you about the recently discovered Poised Realm. It is now known that decoherence can happen and recoherence can happen as well! So a system can hover reversibly between the quantum and classical world. The possibility of recoherence is assured by a theorem and has been observed experimentally. In addition, a decohering quantum variable can be made coherent again by quantum measurement, which is not recoherence.
Given the above, a "quantum mind" can have acausal consequences for the meat of the brain. We can thereby break the stalemate since Descartes and Newton. Mind need not be epiphenomenal, for measurement and decohrence can alter the classical world. I would stress, however, that there are multiple interpretations of quantum mechanics, beyond the Copenhagen interpretation, which is roughly standard, and that it is not certain among physicists what the "classical" world is. Whatever the classical world may be, it does not seem to alter the conclusions above.

RC: I can see how you escape the stalemate with the acausal consequences due to measurement and decoherence and recoherence of a "quantum mind" for a "classical" brain. But how does that get us to consciousness?

SK: I will aproach this in two ways: First, following Roger Penrose and Henry Stapp, I propose that conscious experience is related to quantum measurement. This is experimentally testable. We can anesthetize fruit flies with ether. Therefore we can select fruit flies for generations for those that need little or no ether to be anesthetized. The selected flies are the mutant population and the unselected flies are the wild populations. We can now use gene sequences to find the mutated proteins in the mutated population and wild type population and test if the mutated proteins encoded by those mutated genes failed to carry out some kind of quantum measurement that the wild types do carry out. If we found this it would evidence that quantum measurement is associated with conscious experience. Suppose so, then I can imagine quantum effects in neurotransmitter receptor complexes in synapses mediating consciousness and also altering transmembrane potentials in the dendrites connected anatomically to the synapses, thence altered potentials in the dendrites propagate to the nerve cell and trigger or do not trigger the nerve to fire their axons. In short, if the above is true, the working brain includes quantum measurement effects and thence consciousness, in, perhaps, synapses.

RC: But are there other grounds to relate quantum measurement to conscious experience?

SK: Yes, the astonishing Strong Free Will Theorem of John Conway and Simon Kochen: A physicist can choose, using an apparatus, to prepare an electron such that, upon measurement, it will be found to be either spin left, or spin right. Or the physicist can choose to prepare the electron so that upon measurement it will be found to be either spin up or spin down. The Strong Free Will Theorem states that if the physicist has free will then:

i. Nothing in the past of the universe determines the outcome of the measurement, spin up or spin down.
ii. There can be no mechanism of measurement.
iii. The electron "decides" to be found upon measurement to be spin up or to be spin down! The conclusion that the electron "decides" ie has free will, is astonishing and the only place I know in physics where an experiential term, "decides" arises in a theorem.

If the Strong Free Will theorem holds, we have "deciding" upon measurement, the deciding alters the becoming of the universe, and possibly conscious experience occurs as well upon measurement or before it, leading to a panpsychism.

But the Strong Free Will Theorem is circular, it assume the physicist has free will. I think this circularity can be broken with entanglement in quantum mechanics. Briefly, if we are classical, we have no free will. If we invoke a random quantum event which is "free", we have free will, but not a responsible free will. The response I like is this: For N entangled quantum variables, the measurement of the first changes the probabilities of the outcomes of the measurement of the second, and that measurement outcome changes the probabilities for the outcome of the third measurement and so on until all N entangled particles are measured. So the "set" of N measurements are not independent. I think this is an ontological basis, not yet experiential, for a responsible free will and it breaks the circularity of the Strong Free Will theorem. If so, then electrons do freely "decide", an experiential term, the first step in physics towards our experiential pole missing since *Res cogitans* failed.

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