"Just Like Elsa... But Not In A Box."

SPHEX Club Presentation

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All good SPHEX papers have mysterious titles, and all great SPHEX papers have mysterious content. Therefore, in my attempt to produce the best SPHEX paper within my abilities, I am not going to reveal my thesis. Instead, I ask forbearance as I introduce several interesting concepts that, although seemingly disparate, will tie together by the end of the presentation.

PART ONE: QUANTUM MECHANICS AND THE DOUBLE SLIT EXPERIMENT

When I first took chemistry in middle school, and much to my chagrin when my daughters more recently took advanced chemistry in high school, we were introduced to the traditional Bohr model of the atom. According to this view of the atom, each atom is presented basically as a miniature solar system. The nucleus contains protons and neutrons, all of which are considered discreet particles that are held together at the center of the atom, and electrons furiously orbit the nucleus in specific patterns. Furthermore, the number of electrons in each orbital array, or valence, is subject to specific physical laws and the inter-relation of the electrons explains the interaction of different elements and the types of bonds that are possible between different atoms. The electrons themselves are pictured as minute particles, like tiny planets, that orbit the nucleus in defined trajectories.

The problem with this model of the atom is that it asserts that electrons exist as tiny particles that occupy a specific location at a specific time and that move around the nucleus in definable trajectories. There is no doubt that the electrons are highly energetic and that they move very quickly, but they are still objects in motion and it can be said of them that if we were able to freeze time for an instant, we could locate the electrons at some point in space. This model of the atom turns out to be entirely incorrect, and this fact has been demonstrated not only on the basis of theoretical calculation, but also in repeatable empirical tests.

The most famous experiment that has been performed on the electron is known as the double slit experiment. According to the protocols of this experiment, an apparatus is devised that can shoot a single electron at a time in a specific direction. Across from the 'electron gun', scientists are able to place a detection plate that can record where the electron hits after it is emitted. In between the electron emitter and the electron detector, we can place an impervious material that blocks the electron's path. However, rather than leaving the barrier entirely impervious, we cut two slits into the material through which the electron can pass. Now, when we fire off an electron, we can record where on the detector it lands and infer which slit the electron passed through. If it passes through the left slit, it will land at a certain place on the detector. If it passes through the right slit, it will land in a different spot. Furthermore, we can open or close either slit at will, and thus 'force' the electron to land at a particular place on the detector.

This experiment has been done on a number of occasions and the curious results that it creates are of great interest. In order to understand the results, however, it is worth noting that objects of different types will produce different results when passing through a double-slitted barrier. If we pass a number of discrete particles through the two slits, we should see that they all land in two tightly packed groups on the other side – one group that passed through the left slit and one group that passed through the right slit. On the other hand, if we send a wave toward the barrier, just like a wave in water, the energy of the wave would pass through the two slits, creating two new waves on the far side, that would interact with one another as they spread back out on the far side of the barrier prior to hitting the detector. Picture the ripples in a pond created when you throw a stone in the water. The ripples radiate out and sometimes encounter barriers, like a log in the pond. The wave cannot pass through the log, but once a section of the wave that passed to the left of the log and a section of the wave that passed to the right of the log both move beyond the log, they then interact with one another and create a new wave on the far side. That new wave will have a distinct character that can be measured. In fact, the interaction of the two new waves will create an "interference pattern" based on the way in which the crests and troughs of the waves intersect.

The interesting thing about the two slit experiment is that by arranging the slits in various configurations and combinations of openness, it is possible to produce a result that appears to show that the electrons are individual particles that pass through one or the other slit. For instance, if I open the left slit only and fire electrons at the detector, the concentration of 'hits' behind the left slit indicates that the particles passed through the left slit one by one and collected in a constrained area on the far side of the partial obstruction. Likewise, if I close the left slit and open the right slit, I measure a concentration of particles on the right side of the detector. However, it is also possible to generate interference patterns that indicate that the electrons are not individual particles that passed through only one slit, but actually waves that passed through both slits and recombined on the far side to produce prototypically wave-like interference patterns. When I fire a series of individual electrons at a barrier that has both slits open, I do not end up with two clumps of electron hit-points on the far side, which would indicate that some electrons went through one slit and other electrons went through the other. Instead, the interference pattern shows that each electron went through *both* slits in the manner of a wave.

The reader might not be too impressed with the two slit experiment at this point, because we should point out that even though we shot discrete individual electrons one at a time from an emitter, and they seemed like particles when we did so, the experiment shows clearly that the electron acted like a wave when it encountered the barrier. Furthermore, even waves that go through single slits will create high energies in a single strip on the detector, which is a result that looks very similar to what happens when you fire particles through a single slit. Perhaps what appears to be a particle when it leaves the emitter was actually a wave all along. We might wonder why electrons look to us like particles when we emit them, but still believe that appearances can be deceiving and that electrons are actually waves.

Scientists wanted to verify the possibility that the electron was actually passing through both open slits simultaneously like a wave, so they added an observation to the double slit experiment. When they attempted to observe the electron going through the slits, the interference pattern went away! Let me repeat this point. When we shoot single electrons at a double slitted barrier without watching which slit they each pass through, the resulting pattern of hits on our detector indicates that the electrons were waves that went through both slits and created an interference pattern on the far side. When observe the electrons going through the slits, however, they only go through one or the other at any one time and they make particle-like non-interference patterns on the detector. The results of the experiment are clear and have been replicated on numerous occasions. ***Electrons behave like particles when they are under observation, but they behave like waves when they are not observed!***

Counter intuitively, based on empirical findings, it has been determined that under certain circumstances the electron behaves like a particle, but that under other circumstances it behaves like a wave. The old Bohr model of the atom that has us picturing the electron like a tiny particle in orbit around a sun-like nucleus is wrong. Electrons are not particles. On the other hand, we cannot just replace the particle view of the electron with a wave view, because the electron isn't really a wave either. The electron is sometimes a particle, and sometimes a wave, depending on how it is observed. The electronic seems to have a schizophrenic nature and is either sometimes a particle and sometimes a wave, or something completely different than any type of thing that we have ever imagined -- a wavacle! The nature of the electron seems to be paradoxical.

PART TWO: HEISENBERG'S UNCERTAINTY PRINCIPLE

One way to state the paradox created by the two slit experiment is to say that the wave-particle duality of the electron indicates that when we measure it in one way we can define certain characteristics of the electron, but that when we measure it in another way we can define different characteristics of the electron. This fact gives rise to the famous Heisenberg Uncertainty Principle that was developed in 1927. According to the Heisenberg Uncertainty Principle, the electron cannot properly be said to have a specific position and simultaneously have a specific momentum. If we measure one, the other becomes indeterminate. If we measure the other, the first becomes indeterminate.

It is extremely important not to confuse Heisenberg's Uncertainty Principle with a simple observer effect. People often believe that the principle merely indicates that when an observer interacts with a particle to measure it, the act of measurement disturbs some property that the particle previously had. Thus, when we measure position we disturb momentum, and when we measure momentum we disturb position. This results in the fact that we cannot measure both position and momentum simultaneously. This understanding of the Uncertainty Principle is incorrect.

What Heisenberg actually discovered is that prior to measurement, an electron cannot be said even to have a discrete position or a discrete momentum. It is the act of observation itself that *causes* those properties to come into existence. Thus, according to Heisenberg, it isn't that an observer disturbs a system that previously had an unmeasured but determinate position and momentum. To the contrary, the electron existed in a probabilistic state up until the time that one of its properties was measured. At that moment, the measured property became fixed to some degree of precision, but the complementary property became probabilistic to an offsetting degree. Consider as an analogy the shape of a radio wave. We know that radio waves have wavelengths (frequencies) and we know that they exist in time. If we want to be very precise about when a wave exists, we need to pin it down temporally. However, once we take a time-slice picture of the wave and fix the height of its crest, the wave no longer has a frequency because that concept requires a pattern to exist through time. On the other hand, if we decide carefully to measure frequency, we must examine a wave through time, and our precision as to when it exists is diminished.

Uncertainty pairs are not restricted to position and momentum. Quantum mechanics also recognizes an uncertainty principle with regard to time and energy. Although a particle must have a conservation of matter and energy over time, if the times are short enough, the energy uncertainty can be very large. Thus, for extremely short periods of time, particles can actually come into existence from nothing, as long as they then go out of existence within the prescribed temporal limits. These "virtual particles" have actually been measured and can be said to exist.

Back to Heisenberg. One way to illustrate the true uncertainty, indeterminacy, or probabilistic nature of reality that quantum mechanics dictates is to examine the 'collapse of the wave function'. If it is true that an electron doesn't really have a position or momentum until measured, all that we can say about an electron at any given moment is that it has a probability of being in a certain location or having a certain momentum at any particular time. Imagine an electron that is confined in a restricted space (around the nucleus of an atom, for instance). We can't really say that the electron is in any particular location, but we can mathematically describe the odds of it being in any location at any given time. Given the nature of atoms, the electron can inhabit more or less stable orbits around the nucleus and the odds are much higher that it will be in a more stable orbit rather than a less stable orbit. Nevertheless, the electron has a non-zero probability of being in some pretty unexpected locations (like on the other side of the universe).

Mathematically, if we were to draw a graph that showed position on one axis and time on the other, the plot of probable locations of the electron over time would form the shape of a wave. Higher probability locations would form a bump in the middle of the wave, and we would have something that looked like a bell curve. Once an observation of position is made, however, the probability of the electron being in the observed location becomes 100% and the probability that it is in any other location becomes 0%. At that moment, the wave function is said to have collapsed. Notice, however, that when we nail down the position with precision, we lose all precision in measuring the particle's momentum. In fact, the particle cannot be said to have even an unmeasurable momentum.

The Heisenberg Uncertainty Principle has been proven experimentally, and is a necessary fact for the operation of many engineered devices that we rely on today, including the semi-conductors that make the word processor upon which this paper was written.

PART THREE: THE IMPOSSIBILITY OF FREE WILL

There is no question that human beings have a long history of tenaciously maintaining belief in purported facts that are manifestly and demonstrably untrue. One of the most deeply held and thoroughly indefensible human beliefs is in that capacity which we call 'free will'. Most people believe that they have the ability to direct their own thoughts and actions, and that they enjoy great liberty in doing so. As philosophers have long shown, the belief in free will, as it is normally construed, is irrational.

The standard argument against the concept of free will rests on the idea that the concept itself is logically inconsistent. In order to have true free will, it must be the case that a person is able to cause his own choices to be as they are, free of outside constraints. The problem with this concept is that choices are mental states -- a type of event -- and it is assumed that all events are caused. If choices are caused, then we are not free to make choices other than those that result from the previous causal conditions. Therefore, we are not free. On the other hand, if we simply assert that choices are uncaused, then we must believe that choices are random. If choices are random, then they are fully uncaused and out of our control. The choices might then be free, but they clearly aren't choices. The argument therefore concludes that on either assumption, that mental states are caused or uncaused, the concept of free will is unintelligible.

PART FOUR:
A FIRST ATTEMPT TO GENERATE FREE WILL FROM QUANTUM MECHANICS

The argument for free will receives some support from quantum theory, but the standard use of quantum mechanics is insufficient to alleviate the previously mentioned conundrum. In light of quantum mechanics one might argue that if it is true that certain properties of objects are indeterminate until an observer interacts with them, then the observer must be free to interact in a variety of ways. Otherwise, the properties of the object would be as fixed as the intent of the observer. Therefore, true quantum randomness implies freedom on the part of the observer.

In response to this argument, it is possible to retort that our thoughts might be set deterministically by pre-existing conditions such that they could not be otherwise, and that we will, therefore, invariably observe as we do. Nevertheless, this fact will not be reflected in the wave function of unobserved properties of particles. Therefore, it is possible that a particle's properties are indeterminate at a given moment, although it is simultaneously true that the wave function will invariably be caused to collapse in a determinate way based on the forces that previously interacted with the observer who will collapse the wave function. This fact would allow an outside observer effectively to predict the future by knowing what the actual properties of a particle will be, even when those properties are currently indeterminate. This would support the view that quantum physics does not imply free will.

One could then counter-argue that, ultimately, true free will must exist. Otherwise the wave function of a particle would be entangled with the wave function of the observer such that there is no indeterminacy of the combined wave function (i.e. all wave functions would instantly collapse at the moment of the first observation). The only way to have true indeterminacy is to posit true free will for the observer so that the entangled wave function is still indeterminate. In fact, most proponents of the idea that quantum mechanics creates room for free will rely on the very fact that quantum reality contains indeterminacy. The argument claims that since the properties of certain objects are indeterminate, the way that their wave function collapses must be, at some level, random. The existence of randomness in the universe might be troubling to some, but many have taken it as an opportunity to save free will. Quantum mechanics generates the possibility of uncaused (i.e. random) physical properties. Free will could be the result of quantum states within neurons that are uncaused by antecedent conditions, and are thus unconstrained and free.

Unfortunately, this line of reasoning fails to support true free will. If thoughts need be only random in order for the argument to go through, then while we must agree that conscious entities have freedom, we lose the ability to show that they have will. Will involves intention, and the acceptance that certain thoughts are merely the result of quantum uncertainties within neurons does not show that we have control over our intentions, but only that our intentions are uncaused. The best we can get, then, is soft determinism[1]. We certainly make choices, and in one sense they are free, but our choices are not within our control. Rather, they are random within the bounds of the wave functions of our individual brains.

PART FIVE: SCHRODINGER'S CAT

During the years that followed Heisenberg's work, physicists worked on a number of ways to interpret the meaning of uncertainty, and some rejected the concept because it implied insoluble paradoxes. Three physicists, Einstein Podolsky and Rosen, published a paper in 1935 describing the implications of the uncertainty principle. The now famous "EPR Paper" explained clearly that if Heisenberg were correct, then particles could exist in "superposition" prior to observation and the collapse of the wave function. The state of 'superposition' makes sense if one thinks about the fact that, according to Heisenberg's Uncertainty Principle, it can't really be said that an electron exists in a particular location until a measurement is made. Rather than saying that the electron doesn't exist in either location A or location B at a particular time, it makes sense according to EPR to say that the electron is in a superposition at a particular time that includes both positions A and B. When a measurement is made, and the electron is located in either position A or B, the observation reduces the probability to reality and superposition collapses into physical location.

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[1] The term 'soft determinism' was first coined by William James in his essay "The Dilemma of Determinism", in which he argued against the position. The term attaches to a broader set of views known collectively as 'compatibilism' and traces its history back through Mill, Hume, Hobbes and the Ancient Greeks. Compatibilists argue that an action can be free in the important sense of not being compelled by an outside force while at the same time being subject to personality traits that are caused by antecedent conditions. An excellent contemporary treatment of the issue is Elbow Room by Daniel Dennett, MIT Press, 1984.

One physicist who was not comfortable with the implications of the EPR paper, and therefore with the Heisenberg Uncertainty Principle itself, was Erwin Schrodinger. In 1935, Schrodinger introduced the following thought experiment:

> A cat is penned up in a steel chamber, along with the following device (which must be secured against direct interference by the cat): in a Geiger counter, there is a tiny bit of radioactive substance, so small that perhaps in the course of the hour, one of the atoms decays, but also, with equal probability, perhaps none; if it happens, the counter tube discharges, and through a relay releases a hammer that shatters a small flask of hydrocyanic acid. If one has left this entire system to itself for an hour, one would say that the cat still lives if meanwhile no atom has decayed. The psi-function of the entire system would express this by having in it the living and dead cat (pardon the expression) mixed or smeared out in equal parts.[2]

In other words, Schrodinger rightly concludes that if superposition is true, the state of the radioactive decay in a closed system is not determined until a measurement is made. According to EPR, the radioactive decay can't be said to have either happened or not happened prior to observation, but must be considered to be in a superposition including both the state of having happened and not having happened. When an observation is made, the wave function will collapse and the reality of radioactive decay, or lack thereof, will be established. In Schrodinger's example, however, there is a macroscopic result based on the potential radioactive decay, namely the death of a cat. Until the observation is made, according to uncertainty, the radioactive decay neither happens nor doesn't happen. Therefore, until the observation is made, the cat is neither dead nor not-dead. Or, to state this more consistently with the EPR, the cat is in a state of superposition which contains a state of both being dead and not being dead. When we open the box and make an observation of the Geiger counter, we will collapse the wave function and the state of the cat as being either dead or alive will be determined. Contrary to the scientific evidence to the contrary, Schrodinger can't wrap his head

[2] E. Schrödinger, "Die gegenwärtige Situation in der Quantenmechanik", *Naturwissenschaften* 23: pp.807-812; 823-828; 844-849 (1935). "The Present Situation in Quantum Mechanics" translated by John Trimmer: Proceedings of the American Philosophical Society, 124, 323-38.

around the possibility that the cat exists in a mixed state until observed, and he takes this as a counter argument to quantum uncertainty.

It is worth noting that physicists have worked on several interpretations of the Uncertainty Principle in order to deal with Schrodinger-style results. The Copenhagen Interpretation actually accepts superposition and wave function collapse, but physicists adopting this interpretation do so in a number of different ways. Some simply refuse to think about what the interpretation means about underlying reality, and restrict themselves to commenting only on what can be observed. They don't even try to interpret this material, they just report the empirical results of experimentation (cop-out!). Others, Like Neils Bohr, assert that the Geiger counter does its own measurement which is sufficient to collapse the wave function. This type of argument can be expanded into a class of interpretations known as Objective Collapse Theories that maintain that quantum uncertainty is constrained within certain limits so that when temporal, mass or temperature thresholds are met, wave functions spontaneously collapse.

The Many Worlds Interpretation stands in stark contradistinction from the Copenhagen and Objective Collapse Theories. This view holds that when the cat is placed in the box, two possible futures exist for the cat -- one in which it is alive and one in which it is dead. The universe actually splits at that point in time, so that one universe contains the living cat and one universe contains the dead cat. When an observer opens the box, he/she observes the state that obtains in his/her universe. Another observer in an alternate universe observes a cat in a different state. In this way, the wave function doesn't actually collapse upon observation, but an infinite number of alternate realities simultaneously exists.

Other interpretations of the Schrodinger's Cat paradox have been developed, but it is not my goal in this paper to discuss them exhaustively. My point is merely to acquaint the reader with the paradox and to demonstrate that almost all interpretations are mind-bending. The experimental evidence for uncertainty is undeniable, and rather than creating a counter-example to it, Schrodinger has contributed to its mysteries.

PART SIX: BACKWARD CAUSATION

The discussion up to this point is based on several assumptions that have gone unstated. They may seem beyond question, but if I have accomplished nothing else tonight, I hope that I have at least demonstrated that basic common sense assumptions about the nature of reality should not be taken as being above suspicion. Let's consider three common assumptions and their implications for free will. First, that time actually exists as a property of our universe. Second, that a flow of time exists that moves inexorably from past to future, such that causation can move only in one direction; from past to future. Third, that since our minds exist within the flow of time, their actions must be either caused (and thus not free), or random (and thus not willed). Upon further consideration and research, however, it turns out that even these extremely intuitive assumptions are most likely untrue.

While the concept of time itself has been under attack since the development of special relativity shortly after the turn of the last century, many of the scientific theories that were advanced merely argued that the variable of time was either subjective as a matter of perspective in relativity theory, or completely unnecessary for calculations of quantum mechanics.[3] In other words, scientists over the last 100 years have been able to show either that time does not behave in the objective way that it appears, or that the universe can be described completely without reference to a temporal component. While the elimination of a constant, objective notion of time has been conceptually difficult, it did not necessarily advance any argument regarding the existence of free will. That is, until recently.

On a conceptual basis, if we think carefully about thought experiments like Schrodinger's Cat, the most amazing conclusion should not be that our observation establishes the collapse of the wave function and thus sets the reality of the cat's life or death, but rather that it seems to do so counter to the perceived flow of time. It is important to note that when an observer collapses the wave function of an observed

[3] "Is Time an Illusion?" in Scientific American, June 2010, Vol 302 Number 6, pp.59-65

phenomenon, not only does she establish the present state of the system, but she also establishes the history of that system. Consider what happens if we extend the example of Schrodinger's Cat so that the experiment takes place over a five day period. We set up the box and the cat on Monday, but we don't open the box and observe the cat until Friday. Now there will be a probability of some predictable degree that, once observed, the wave function of the closed system will be such that the cat died on Monday and decomposed, unobserved, until Friday. However, according to quantum theory, the reality of the cat's status won't be set until the system is observed on Friday. Therefore, when I open the box and observe the box on Friday, not only do I establish whether the cat is alive or dead, but I also determine *when* the cat died and *for how long* it has been decaying. I have not only set the reality of the cat's status at the time that I observe it, I also set the reality of a string of events, the history, that unfolded from the moment of the cat's death onward. I create a week's worth of history at the instant that I open the box and observe the cat. My observation reaches *backward in time* to affect a string of events that takes place *throughout time*.

The realization that, according to quantum mechanics, my observations not only collapse a wave function at a moment in time, but also establish a history of events through time, has startling implications. What works for the cat over the course of a week also works for dinosaurs over the course of eons. When we dig up an hitherto unobserved fossilized footprint and observe it, we not only establish its reality, we establish the reality of the history of the dinosaur itself, and the history of the world that included that dinosaur. Quantum mechanics seems to imply the power of an observer to create history. It seems to entail the notion that backward causation is not only possible, but necessary.

Amazingly, the possibility of backward causation is not only conceptually defensible based on theoretical considerations of quantum mechanics, it is scientifically testable. Although my mathematical skills are extremely limited, I believe that I do understand the concepts presented in some recent work on this topic.[4] I will attempt to explain the concept of backward causation in normal language.

Consider a pool table in a locked room that is immune from any new outside forces, that has a number of balls on its surface and one cue ball moving in a particular direction with a particular speed. Imagine that we know, with great precision, the coefficient of friction of the felt table, the mass, volume and mechanical properties of each ball, the elastic properties of the bumpers, the energy of the moving cue ball, and any other minute detail that you can imagine. Classical physics said that, given complete understanding of the information provided about the pool table at time T, and the necessary computational capacity and familiarity with physical law, it is entirely possible to predict the state of the pool table at any future time T'. This is not only the view of classical physics, this is the common sense view. According to this view, all future states of affairs of the pool table are caused by predecessor states so that full information about preceding conditions yields accurate information about subsequent states of affairs. Given accurate enough information about an initial state of affairs and any forces acting on that state of affairs, we can accurately predict subsequent states of affairs.

If a quantum mechanical view of reality is correct, however, the ability to predict future states of affairs by considering prior conditions no longer exists, at least on the atomic level. Since certain "particles" do not have definite positions and momentums, but only probabilistic positions and momentums until measured, there is only a probability that they will exist in any particular location or have any particular momentum once they are actually observed. In other words, quantum mechanics allows that "identical measurements of identically prepared systems can yield different outcomes".[5] This fact has been well established at the sub-atomic level, and more and more experimental evidence seems to allow it for ever larger and larger macroscopic systems. The outcome is that given two identical pool tables, with identical properties and identical moving cue balls, it is possible that after the cue ball completes its travels and interactions, the two

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[4] "A time-symmetric formulation of quantum mechanics" by Aharonov, Yakir et. al. in Physics Today November, 2010 pp.27-32.

[5] ibid p. 27

pool tables will end up with the pool balls in different configurations. This fact alone is mind-boggling, but it isn't even the most relevant philosophical implication of quantum mechanics.

Physicists have recently developed a method for making "weak measurements". This system of measurement trades off accuracy for a reduction in the observer effect. According to the Heisenberg Uncertainty Principle, the more accurate an observation becomes of one set of entangled properties, the less determinate a paired property becomes. If I test for location, thus collapsing the wave function of location, the property of momentum is correlatively impacted with a decrease of determinacy and vice versa. However, by doing very weak and indirect observations, I can reduce the specificity of my observation and thus reduce the degree to which I collapse the wave function. While my observation will have a margin of error regarding any particular particle being observed, the error will not be significant over a large number of observed particles. This gives me the power to make weak observations of large numbers of particles that will have very low specificity with regard to any single particle, but very high predictive value for the system as a whole. Accordingly, I can 'know' with a high degree of probability what certain properties of a system are without actually collapsing a wave function.

Weak observation allows an observer to derive statistical information about a system without appreciably altering that system. We can then make observations at multiple times and determine their predictive effect. Amazingly, experimental data shows that, on at least the mathematically simplest interpretation, a later observation actually changes the state of affairs that existed at an earlier time. The experiments that show this are complex, and they depend on creating a system by pre-selecting for certain properties. The objects are then post-selected based on certain properties that are statistically improbable but possible. Between the pre and post selection, a weak measurement is made. Experimentally, it turns out that the post-selection action always correlates with a particular weak measurement. In other words, our choice after the fact to look at a particular particle actually changes the total energy of the complete system at a time prior to the post-selection observation. We have backward causation. An event that takes place later in time actually changes what happens earlier in time!

Yakir Aharonov and his collaborators have introduced the idea that quantum physics not only allows, but actually requires "multiple-time states" and "multiple-time measurement states".[6] These multiple-time measurements imply that a measurement taken at one time can actually have a causal impact at what we take, given the intuitive flow of time, to be a prior state. This concept can be interpreted as backward causation, and it threatens our common-sense notions of the flow of time.[7]

The discovery of backward causation challenges the entire notion that time has a unidirectional flow and that causes are always temporally antecedent to effects. This fact demonstrates that any creature that is capable of collapsing the wave function of observed phenomena must posses an extra-temporal element that, in a very real way, contributes to the creation of reality. Such beings possess a deeply free, permanently existing and creatively active perceiving property.

PART SEVEN: FREE WILL AND IMMORTAL SOULS TO BOOT

The existence of backward causation, which should have been identified immediately upon the development of quantum theory, settles two of philosophy's greatest metaphysical puzzles in a single stroke. First, backward causation entails the existence of some aspect of an observing being that stands outside of the flow of time. This aspect, being extra-temporal, cannot be said to come into existence or go out of existence at any moment in time. Therefore, this aspect of an observing creature must be immortal. We must possess immortal "souls". Since we know that our bodies are not immortal, and we now know that some aspect of us is immortal, dualism is logically established. Our bodies and our wave-collapsing observing aspects must be separate, and the latter must be completely unfettered by the ravages of time that beset the former.

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[6] "Multiple-time states and multiple-time measurements in quantum mechanics" by Aharonov, Yakir et. al. in Physical Review A 79 (2009) pp. 052110-1-052110-16.
[7] "Back From The Future" by Merall, Zeeya in Discovery April, 2010 pp.38-44.

Second, by establishing that some component of our being exists outside of time, backward causation also creates an opening for that particular aspect of our composite existence to work freely from the constraints of the uni-directional, future oriented temporal flow. Free from temporal flow, it is no longer possible that any state of affairs in our perceiving aspect can be conceived of as the consequent caused by an antecedent. Neither can it be considered as randomly appearing without prior cause. Our observations of reality are neither caused nor random. Our observing capacity must be considered extra-temporal and free. If we accept the view that our perceptions collapse a wave function, and we accept the view that wave functions can be collapsed backwards in time, then the perceiving aspect of conscious creatures that makes observations capable of collapsing the wave function exists outside of the normal flow of time. That small part of us will not be constrained by the flow of time, and it will thus be immortal.

When we collapse the wave function, that action must be viewed as a permanently existing comprehensive act of will. Quantum mechanics has proven that any creature that is capable of collapsing a wave function[8] must have a truly free and completely immortal mental existence. We have free will and immortal souls that exist separately from our bodies.

The steps in my argument to reconstruct the concepts of free will and the immortality of the soul are as follows:

1) Quantum Mechanics implies backward causation (collapse of the wave function secondary to perceptive observation establishes the history of a phenomenon), and recent experimental data demonstrates that backward causation might be experimentally verifiable.[9]
2) The plausibility of backward causation demonstrates that the flow of time, at least as it applies to that aspect of our beings that is capable of collapsing a wave function, is illusory. Our observations actually establish history, so the history

[8] The class of entities that has this capacity has still not been defined. It is unclear whether consciousness is a sufficient or necessary condition for wave function collapse. Until a better understanding of what an 'observation' actually amounts to, it is difficult to know how large the class of beings is to which this argument applies.
[9] More experimental data is needed to prove backward causation, but existing data indicates the plausibility of backward causation. The implications for free will will become more forceful as backward causation is tested and verified.

that seems to establish our observations does not, in any intrinsic way, flow from past toward future.

3) If some aspect of our beings exists which is not constrained by the flow of time, then that aspect, tautologically, transcends the flow of time. An aspect of us that transcends the flow of time exists outside of time and is "timeless" or a-temporal.
4) That aspect of us that is a-temporal is the consciously perceiving portion that is capable of collapsing the wave function of the objects that it perceives. Our consciousness is thus "timeless" or "immortal".
5) Without a flow of time, the first standard counter-argument against the existence of free will is substantially weakened. This argument asserts that since all events are caused, and our choices are events, our choices are caused and are, therefore, not free. If we posit the possibility that our current observations actually set history, however, then history does not fully describe the basis for our observations. Some aspect of our being is free from causation because it exists outside of temporal order and does not admit to a prior cause. The concept that all posterior events have antecedent causes does not apply to that aspect of our beings that collapses the wave function.
6) The existence of an uncaused aspect of our actions normally falls prey to a second counter-argument against free will- that if our choices do not admit to antecedent causes then they are random (i.e. taking place at some moment in time without prior cause). Our choices, therefore, are out of our control. This argument states that without antecedent causation our choices might be free, but then nothing caused them, not even ourselves. Therefore, while we might not be constrained by prior conditions, we have no ability actually to choose our actions and thus we have no will. This second counter-argument fails, however, once we realize that the arrow of time is not objective. The argument is based on the fact that causes pre-date effects and that our decisions are effects that must either be caused or random. However, if certain specific actions transcend time itself, then they do not take place 'at a moment' in time. They are permanent states of willfulness that cannot be said to come into existence or go out of existence within the flow of time. They are instantaneous and permanent states of will.
7) The argument created so far concludes that A) some aspect of us that is capable of collapsing wave functions upon observation must transcend the flow of time and time itself. This aspect of our beings will be permanent and temporally infinite, since, by transcending all moments, it could not have come into existence 'at some moment in time' and it can't go out of existence 'at some moment in time'. B) This aspect of our beings will also be free, since it won't be susceptible either to causes or random fluctuations. Both causes and random actions take place in time, and the relevant aspect of our beings transcends time. This aspect of our being cannot be assailed by arguments against free will. Based on (A) and (B) we should now recognize that the relevant aspect of our beings is 'free will'

In conclusion, we can say that every creature capable of collapsing a wave function has both a 'will' and a 'meta-will'. The will is that mental aspect of us that is temporally causal. The meta-will is that aspect of us that is a-temporal and causally free. Any creature capable of collapsing a wave function is tri-partide. In an attempt to map this taxonomy onto normal language, it might be fair to say that human beings, and potentially other perceiving organisms, are made up of three parts: the body, the mind, and the soul. The body is material, the mind is a supervenient property of the body, and the soul is that aspect of us that exists extra-temporally and has radically free will.

To explain my title "Just Like Elsa... But Not In A Box": I am, apparently, born free. Fortunately, this cat does not belong to Schrodinger.

"Just Like Elsa... But Not In A Box."

SPHEX Club Presentation

Michael A. Gillette, Ph.D. February 17, 2011

The steps in my argument to reconstruct the concepts of free will and the immortality of the soul are as follows:

1) Quantum Mechanics implies backward causation (collapse of the wave function secondary to perceptive observation establishes the history of a phenomenon), and recent experimental data demonstrates that backward causation might be experimentally verifiable.[1]
2) The plausibility of backward causation demonstrates that the flow of time, at least as it applies to that aspect of our beings that is capable of collapsing a wave function, is illusory. Our observations actually establish history, so the history that seems to establish our observations does not, in any intrinsic way, flow from past toward future.
3) If some aspect of our beings exists which is not constrained by the flow of time, then that aspect, tautologically, transcends the flow of time. An aspect of us that transcends the flow of time exists outside of time and is "timeless" or a-temporal.
4) That aspect of us that is a-temporal is the consciously perceiving portion that is capable of collapsing the wave function of the objects that it perceives. Our consciousness is thus "timeless" or "immortal".
5) Without a flow of time, the first standard counter-argument against the existence of free will is substantially weakened. This argument asserts that since all events are caused, and our choices are events, our choices are caused and are, therefore, not free. If we posit the possibility that our current observations actually set history, however, then history does not fully describe the basis for our observations. Some aspect of our being is free from causation because it exists outside of temporal order and does not admit to a prior cause. The concept that all posterior events have antecedent causes does not apply to that aspect of our beings that collapses the wave function.
6) The existence of an uncaused aspect of our actions normally falls prey to a second counter-argument against free will- that if our choices do not admit to antecedent causes then they are random (i.e. taking place at some moment in time without prior cause). Our choices, therefore, are out of our control. This argument states that without antecedent causation our choices might be free, but then nothing caused them, not even ourselves. Therefore, while we might not be constrained by prior conditions, we have no ability actually to choose our actions and thus we have no will. This second counter-argument fails, however, once we realize that the arrow of time is not objective. The argument is based on the fact that causes

[1] More experimental data is needed to prove backward causation, but existing data indicates the plausibility of backward causation. The implications for free will will become more forceful as backward causation is tested and verified.

pre-date effects and that our decisions are effects that must either be caused or random. However, if certain specific actions transcend time itself, then they do not take place 'at a moment' in time. They are permanent states of willfulness that cannot be said to come into existence or go out of existence within the flow of time. They are instantaneous and permanent states of will.

7) The argument created so far concludes that A) some aspect of us that is capable of collapsing wave functions upon observation must transcend the flow of time and time itself. This aspect of our beings will be permanent and temporally infinite, since, by transcending all moments, it could not have come into existence 'at some moment in time' and it can't go out of existence 'at some moment in time'. B) This aspect of our beings will also be free, since it won't be susceptible either to causes or random fluctuations. Both causes and random actions take place in time, and the relevant aspect of our beings transcends time. This aspect of our being cannot be assailed by arguments against free will. Based on (A) and (B) we should now recognize that the relevant aspect of our beings is 'free will'