JANUARY 19, 2013 THESKEPTICARENA.COM

THE MANY WORLDS INTERPRETATION OF QUANTUM PHYSICS

BY ELIEZER YUDKOWSKY

*Macroscopic quantum superpositions, a.k.a. the "many-worlds interpretation" was proposed in 1957 and brought to the general attention of the scientific community in 1970. Ever since, it has steadily gained in popularity. As of 2008, Many Worlds may or may not be endorsed by a majority of theoretical physicists (attempted opinion polls conflict on this point). Of course, Science is not supposed to be an opinion poll, but anyone who tells you that Many Worlds is "science fiction" is simply ignorant.*

*When a theory is slowly persuading scientists despite all academic inertia, and more and more graduate students grow up familiar with it, at what point should one go ahead and declare a temporary winner pending new evidence?*

Eliezer, the answer to that question is ... never. There is no need to declare a winner; temporary or otherwise. Science will determine the winner despite your attempt to force a vote on reality. When science has accumulated enough evidence to convince a consensus of physicists that one interpretation is correct, or that a new interpretation is correct, then and only then, can you "declare" a winner.

And what do you think will happen if you declare a winner?

Nothing. Nothing will change. Physicists will go on experimenting and testing theories as they always have. So your rush to declare a winner accomplishes nothing. Your impatience with science being unwilling to crown your personal favorite, betrays the insecurity of your position. Perhaps that is why you trumpet your certainty so loudly.

*Reading through the referenced posts will give you a very basic introduction to quantum mechanics - algebra is involved, but no calculus - by which you may nonetheless gain an understanding sufficient to see, and not just be told, that the modern case for many-worlds has become overwhelming. Not just plausible, not just strong, but overwhelming.*

Eliezer, if your claim were true then there would be overwhelming support for Many Worlds. But there isn't. There is still a large number of physicists who back the Copenhagen Interpretation. Also, there are quite a number of other interpretations. I don't think you are in a position to justify using the word "overwhelming" because there are simply too many physicists who have not been "overwhelmed."

*Single-world versions of quantum mechanics just don't work,*

Eliezer, it all depends on *why* they don't work. They may not work because they are wrong. Or they may not work because physicists have not yet reached the level of understanding necessary to explain all the results they see in their experiments.

And Eliezer, your version only works for you and those who believe as you do. It doesn't work for those scientists ... who don't.

*and all the legendary confusingness and mysteriousness of quantum mechanics stems from this essential fact. But enough telling - let me show you.*

*•Quantum Explanations: Quantum mechanics doesn't deserve its fearsome reputation. If you tell people something is supposed to be mysterious, they won't understand it. It's human intuitions that are "strange" or "weird"; physics itself is perfectly normal.*

Eliezer, I find that description misleading. To paint quantum entanglement as unmysterious and perfectly normal is to paint a false picture of reality. Even the world's greatest scientists, of which you are not one, cannot explain this phenomenon. When the world's leading scientists cannot explain an observation, that defines "mysterious."

*Talking about historical erroneous concepts like "particles" or "waves" is just asking to confuse people; present the real, unified quantum physics straight out.*

So Eliezer, you consider a particle to be an erroneous historical concept? That's odd because physicists still talk about, and experiment with, particles. In fact, recent experiments have just determined the roundest object ever measured in the Universe. Know what it was Eliezer? It was the electron; a particle.

http://www.physnews.com/physics-news/cluster157539222/

*•Distinct Configurations: Since configurations are over the combined state of all the elements in a system, adding a sensor that detects whether a particle went one way or the other, becomes a new element of the system that can make configurations "distinct" instead of "identical".*

*This confused the living daylights out of early quantum experimenters, because it meant that things behaved differently when they tried to "measure" them. But it's not only measuring instruments that do the trick - any sensitive physical element will do ....*

Eliezer, two physicists shared the 2012 Nobel Prize in physics for developing methods that allowed them to make quantum measurements ... without disturbing the system.

*•Where Philosophy Meets Science: In retrospect, supposing that quantum physics had anything to do with consciousness was a big mistake. Could philosophers have told the physicists so? But we don't usually see philosophers sponsoring major advances in physics; why not?*

Eliezer, a better question is why should we? We don't see historians sponsoring major advances in physics either. Why would you even ask such an ignorant question?

*•Can You Prove Two Particles Are Identical?: You wouldn't think that it would be possible to do an experiment that told you that two particles are completely identical - not just to the limit of experimental precision, but perfectly.*

Eliezer, that depends what you mean by identical. The fact that they are not the same object immediately proves they are not identical. For example, even if similar in every respect, they are not similar in their location in space. Therefore the quantum foam surrounding each particle could not possibly be the same; the neutrinos that bombard each particle could not possibly be the same neutrinos; etc.

*You could even give a precise-sounding philosophical argument for why it was not possible - but the argument would have a deeply buried assumption. Quantum physics violates this deep assumption, making the experiment easy.*

Eliezer, there was nothing philosophical about my argument.

*•The Quantum Arena: Instead of a system state being associated with a single point in a classical configuration space, the instantaneous real state of a quantum system is a complex amplitude distribution over a quantum configuration space. What creates the illusion of "individual particles", like an electron caught in a trap, is a plaid distribution ....*

Eliezer, how do you explain how scientists were able to capture and measure your illusion? How were they able to determine every spherical point on the surface of that illusion to an accuracy of 26 decimal places?

Eliezer, that's one hell of an illusion.

*•Feynman Paths: Instead of thinking that a photon takes a single straight path through space, we can regard it as taking all possible paths through space, and adding the amplitudes for every possible path. Nearly all the paths cancel out - unless we do clever quantum things, so that some paths add instead of canceling out.*

Eliezer, "clever quantum things" are unnecessary. The paths nearest the shortest distance will add instead of canceling out.

If an electron is traveling through all possible paths, then these paths must be physically separated. So when a photon strikes an electron, how does it strike all possible electrons at the same time? Does it instantly split into as many photons as there are possible electron paths? Or does it pick one?

*Then we can make light do funny tricks for us, like reflecting off a mirror in such a way that the angle of incidence doesn't equal the angle of reflection.*

Eliezer, the angle of incidence only appears to equal the angle of reflection due to the cancelation of most of the probability amplitudes for the longer paths. However, experiment has shown that some of these probabilities are occasionally realized (that's why they are called 'probabilities'). That is not a "funny" trick Eliezer - it is basic experimental quantum physics.

*But ordinarily, nearly all the paths except an extremely narrow band, cancel out - this is one of the keys to recovering the hallucination of classical physics.*

*•No Individual Particles: One of the chief ways to confuse yourself while thinking about quantum mechanics, is to think as if photons were little billiard balls bouncing around. The appearance of little billiard balls is a special case of a deeper level on which there are only multiparticle configurations and amplitude flows.*

Eliezer, the billiard ball analogy, while not perfect, is a far more accurate representation of reality than amplitude flows which are only mathematical probabilities and not real objects. Scientists can detect and count those little billiard balls you disparage. Probability amplitudes only exist as concepts.

*It is easy to set up physical situations in which there exists no fact of the matter as to which electron was originally which.*

Eliezer, it is also easy to set up physical situations in which particles do not exhibit wave behavior. Why does the fact that photons travel in waves prohibit their existence as individual particles? If there are no individual particles why did you refer to a configuration earlier as "multiparticle?"

*•The So-Called Heisenberg Uncertainty Principle: Unlike classical physics, in quantum physics it is not possible to separate out a particle's "position" from its "momentum".*

Eliezer, before relying too heavily on Heisenberg, you may want to read this first:

http://phys.org/news/2012-09-scientists-renowned-uncertainty-principle.html

It seems Eliezer, that you may have spoken too soon. Maybe that's why you're in such a rush to take a vote.

*The evolution of the amplitude distribution over time, involves things like taking the second derivative in space and multiplying by i to get the first derivative in time.*

Eliezer, isn't "i" the imaginary part of a complex number?

*The end result of this time evolution rule is that blobs of particle-presence appear to race around in physical space. The notion of "an exact particular momentum" or "an exact particular position" is not something that can physically happen,*

Eliezer, then how can a photon strike a photon receptor in the back of the human eye? To make that hit required that the photon get to an "exact particular position."

*•On Being Decoherent: When a sensor measures a particle whose amplitude distribution stretches over space - perhaps seeing if the particle is to the left or right of some dividing line - then the standard laws of quantum mechanics call for the sensor+particle system to evolve into a state of (particle left, sensor measures LEFT) + (particle right, sensor measures RIGHT). But when we humans look at the sensor, it only seems to say "LEFT" or "RIGHT", never a mixture like "LIGFT". This, of course, is because we ourselves are made of particles,*

Eliezer, you mean the particles that you earlier said, don't exist?

*and subject to the standard quantum laws that imply decoherence.*

Eliezer, I can't count the times I've heard physicists say that the classic laws of physics break down at the quantum level. So what evidence do you offer that the laws which operate on a quantum level, apply to us?

*•The Conscious Sorites Paradox: Decoherence is implicit in quantum physics, not an extra law on top of it. Asking exactly when "one world" splits into "two worlds" may be like asking when, if you keep removing grains of sand from a pile, it stops being a "heap".*

Eliezer, nice false analogy. On one hand you use an example of an object dividing; and then try to make it analogous to a continuum.

*•Decoherece is Pointless: There is no exact point at which decoherence suddenly happens.*

Eliezer, that contradicts experimental results that report wave function collapse at the instant a measurement is attempted.

*•The Born Probabilities: The last serious mysterious question left in quantum physics: When a quantum world splits in two, why do we seem to have a greater probability of ending up in the larger blob, exactly proportional to the integral of the squared modulus? It's an open problem, but non-mysterious answers have been proposed. Try not to go funny in the head about it.*

Eliezer, you said "when" a quantum world splits in two. At this point in time, the word should be "if." When you finally get your consensus, then you can change it back to "when."

*•Spooky Action at a Distance: The No-Communication Theorem: As Einstein argued long ago, the quantum physics of his era - that is, the single-global-world interpretation of quantum physics, in which experiments have single unique random results - violates Special Relativity; it imposes a preferred space of simultaneity and requires a mysterious influence to be transmitted faster than light; which mysterious influence can never be used to transmit any useful information. Getting rid of the single global world dispels this mystery and puts everything back to normal again.*

Eliezer, getting rid of science and saying "God did it" also dispels all mysteries and puts everything back to normal again. Like your solution, it's real convenient; but you still haven't offered any evidence that "other worlds" exist.

*•Collapse Postulates: Early physicists simply didn't think of the possibility of more than one world - it just didn't occur to them, even though it's the straightforward result of applying the quantum laws at all levels.*

Eliezer, what evidence justifies applying quantum laws at all levels? In the macroscopic world in which we live, can you point to an example of entanglement? Can you provide an example of anything that exists in a superposition?

*So they accidentally invented a completely and strictly unnecessary part of quantum theory to ensure there was only one world - a law of physics that says that parts of the wavefunction mysteriously and spontaneously disappear when decoherence prevents us from seeing them any more.*

Eliezer, nothing I have read about the conclusions of early physicists strikes me as being "accidentally invented." They strike me as being deeply thought out by the world's greatest scientists.

You also said that they invented their conclusions to "ensure" only one world. But as you yourself admitted earlier, they "didn't think of the possibility of more than one world."

Beautiful contradiction, Eliezer.

*If such a law really existed, it would be the only non-linear, non-unitary, non-differentiable, non-local, non-CPT-symmetric, acausal, faster-than-light phenomenon in all of physics.*

Eliezer, because faster than light phenomena have never been proven to exist, there could not be such a law; so your Straw Man argument failed.

*•If Many-Worlds Had Come First: If early physicists had never made the mistake, and thought immediately to apply the quantum laws at all levels to produce macroscopic decoherence, then "collapse postulates" would today seem like a completely crackpot theory.*

Eliezer, as for crackpot theories, I can think of no theory in history more absurd than the one you are promoting: that when you make a decision in a crowded theater to pass gas ... a new Universe is instantly created.

*In addition to their other problems, like FTL, the collapse postulate would be the only physical law that was informally specified - often in dualistic (mentalistic) terms - because it was the only fundamental law adopted without precise evidence to nail it down.*

Eliezer, the collapse postulate is not an adopted law, so precise evidence is not required to nail it down. If it ever becomes a law, then you'll need the nails.

*•Many Worlds, One Best Guess: Summarizes the arguments that nail down macroscopic decoherence, aka the "many-worlds interpretation".*

Eliezer, what *evidence* do you offer to support macroscopic decoherence or do you just have *arguments* ?

That is exactly the same thing that I am offered by Creationists in lieu of evidence ... arguments.

*Concludes that many-worlds wins outright given the current state of evidence. The argument should have been over fifty years ago.*

Eliezer, but the argument wasn't over 50 years ago; and the argument still isn't over today. What you need isn't more arguments ... what you need is evidence.

*New physical evidence could reopen it, but we have no particular reason to expect this.*

Eliezer, as the 2012 Nobel Prizes proved, you may not have a particular reason to expect more physical evidence, but it continues to pour in, anyway.

Eliezer, one little piece of advice: when one does not have a scientific consensus to backup one's position, the proper path is to shut up and calculate. In other words, stop worrying about declaring victory, and concentrate instead on discovering evidence like those two Nobel physicists just did.

That way Eliezer, if it turns out that you're wrong ... the crow won't taste as bad.

http://lesswrong.com/lw/r8/and\_the\_winner\_is\_manyworlds/

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

THE SCIENCE SEGMENT

Neurons Made from Stem Cells Drive Brain Activity After Transplantation in Laboratory Model

Researchers and patients look forward to the day when stem cells might be used to replace dying brain cells in Alzheimer's disease and other neurodegenerative conditions. Scientists are currently able to make neurons and other brain cells from stem cells, but getting these neurons to properly function when transplanted to the host has proven to be more difficult. Now, researchers have found a way to stimulate stem cell-derived neurons to direct cognitive function after transplantation to an existing neural network.

They showed for the first time that embryonic stem cells that were programmed to become neurons can integrate into existing brain circuits and fire patterns of electrical activity that are critical for consciousness and neural network activity.

The trick turned out to be light. Researchers transplanted human stem cell-derived neurons into a rodent hippocampus, the brain's information-processing center. Then they specifically activated the transplanted neurons with optogenetic stimulation, a relatively new technique that combines light and genetics to precisely control cellular behavior in living tissues or animals.

To determine if the newly transplanted, light-stimulated human neurons were actually working, they measured high-frequency oscillations in existing neurons at a distance from the transplanted ones. They found that the transplanted neurons triggered the existing neurons to fire high-frequency oscillations. Faster neuronal oscillations are usually better -- they're associated with enhanced performance in sensory-motor and cognitive tasks.

To sum it up, the transplanted human neurons not only conducted electrical impulses, they also roused neighboring neuronal networks into firing -- at roughly the same rate they would in a normal, functioning hippocampus.

The therapeutic outlook for this technology looks promising. Based on these results, doctors might be able to restore brain activity -- and thus restore motor and cognitive function -- by transplanting easily manipulated neuronal cells derived from embryonic stem cells.

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

FAMOUS QUOTES

OSCAR WILDE (NO BIOGRAPHY - PREVIOUSLY QUOTED)

“LIFE IS TOO IMPORTANT TO BE TAKEN SERIOUSLY.”