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No Solace in Quantum: Indeterminacy and Collapse of the Wave Function Do Not Explain Consciousness

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No Solace in Quantum: Indeterminacy and Collapse of the Wave Function Do Not Explain Consciousness

Editors' Introduction

For those dissatisfied with scientific models that appear to reduce consciousness to an epiphenomenon, quantum indeterminacy has long inspired popular works suggesting that metaphysical ideas about consciousness and spirituality may be rooted in a mystical dimension underlying the familiar experience of matter. In the world of the ordinary, a material object is something that exists in a specific "here" or "there." In the Copenhagen interpretation of quantum mechanics (Faye, 2019)—now the field's standard explanation—the energy states and locations of bits that make up an atom are *indeterminate* because they exist in multiple states and locations at the same time. Since they do not exist in any specific location, they are considered *nonlocal*. This nonlocality, considered by some to be central to quantum mechanics (e.g., Popescu & Rohrlich, 1992), is also implied within terms such as *nonlocal consciousness* and similarly expansive speculations about unbounded universal mind or consciousness (Dossey, 2015; Pal, 2014) that accord well with some popular contemporary visions of spirituality and consciousness (e.g., Hartelius, 2017).

A complement of quantum indeterminacy is the *collapse of the wave function*—a notion not advanced by Bohr and not formally developed until the 1950s (Faye, 2019; Heisenberg, 1958; Jánossy, 1952). When physicists measure the location of a subatomic particle, it is found to exist in a single location and energy state rather than in multiple locations and states. The standard physics explanation for this is that the multiple possibilities of the particle—described as a probability wave—are thought to collapse into one actual energy state and location (Gao, 2018). This has been interpreted as implying that there is some consciousness within nature that has a degree of choice in the particular outcome of the measurement process (e.g., Stapp, 2001); separately, the collapse of the wave function is sometimes thought to be caused by the measuring observer (von Neumann, 1955/2018). Together, these speculations have inspired decades of books arguing that quantum physics holds evidence for the mysteries of consciousness—and perhaps even spirituality.

Without the tantalizing prospect of answering these existential questions, this rarified area of physics would likely never have become commonplace in the conversations of popular culture. Of course, quantum phenomena are present in everything from the uranium 235 in a nuclear reactor to the atoms in an ice cream bar—and as such are implicit within everything. Yet it is fair to ask whether what happens at the smallest levels of matter has any real explanatory power for consciousness

In the same breath, it is important to question whether there is any great urgency to find scientific proof of consciousness. To be sure, the challenge is an interesting one. But taking note of the conspicuous fact that one has to have consciousness even to deny its existence may give space for a deep breath and a step back, so that

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the evidence for connections between physics and consciousness can be evaluated without a pressing need for scientific affirmation of something so self-evident.

This essay seeks to take that step back and walk through some of the facts often neglected in contemporary discussions of quantum physics and consciousness: how quantum physics started, how the Copenhagen interpretation of quantum mechanics—today the standard interpretation—came about, the ways in which a physics interpretation is different than a physics equation, recent research that may cast quantum nonlocality in a new light, and the real motivation behind Erwin Schrödinger's thought experiment involving a cat locked in a box with a vial of poison (*hint*: it was not written to illustrate the mysteries of the quantum realm). Although aspects of the Copenhagen interpretation may not offer as much consensus about quantum mechanics or insight into consciousness as is often advertised, the essay will end by touching on other aspects of physics that may have real implications for future theories of consciousness.

Before looking at what sort of evidence the subatomic world offers for consciousness, it may be helpful to review how quantum physics was created, and how its discoveries have been interpreted. The word quantum has been romanticized by popular culture so that it has become synonymous with something mysteriously powerful—quantum thrusters power science-fiction spaceships, quantum leaps dazzle with new insights (e.g., Miller & C'de Baca, 2001), and quantum as an adjective implies, "profound," or "awesome," or "intense." These connotations have little to do with what the term quantum means in the context of particle physics.

The term quantum physics comes from work being done on atoms in the early 1900s. Prior to 1900 atoms were just a theoretical construct—an idea that was supported by glimmers of evidence. For example, French chemist Louis-Joseph Proust (1794, 1797) was the first to note that when different elements were combined into chemical compounds, the amounts that would react were always in certain proportions (Fournier, 1999). English chemist and meteorologist John Dalton (1808/2010) extended this insight as his basis for proposing an atomic theory. For example, tin oxide is a compound made, quite reasonably, of tin and oxygen. But there are two types of tin oxide, and Dalton observed that one of them contains exactly twice the amount of oxygen as the other. Similar facts are true for a variety of different compounds. From this Dalton theorized that elements might exist in the form of specific units—for example, that one "atom" of tin might combine with either one "atom" of oxygen, or two "atoms" of oxygen—but not with one-and-a-half atoms of oxygen. In other words, he speculated that elements had to come in tiny packages that each had a specific weight—packages called "atoms." This speculation turned out to be correct, but in the 1800s there was as yet only indirect evidence that such atoms existed.

By the early 1900s the existence of atoms was assumed, and people such as Niels Bohr, Albert Einstein, Max Planck, Werner Heisenberg, Erwin Schrödinger, and Wolfgang Pauli were trying to understand the structure of atoms. The new field of quantum mechanics really began when Max Planck (1900) discovered that only certain relationships between matter and radiation were possible (Nauenberg, 2016). This obscure-sounding idea is really quite simple. Everything absorbs and gives off radiation. If you heat up an iron rod the way a blacksmith does, the iron starts to give off radiation that can be seen as a reddish light. If you heat it up even more, the light turns white. That light is radiation being given off by the iron rod. But the table in your home is also giving off radiation, just like the white-hot iron. This electromagnetic radiation—called *thermal radiation* because it is associated with heat—is at a much lower frequency, and unless your table is on fire, you cannot see this radiation. Normally, the radiation given off by your table is in the range known as infrared, that is, below the frequency of red light. Night-vision goggles work by turning this low-frequency radiation into something the human eye can see. The next time you walk around your home, just think about the fact that everything is radiant with energy—the bookcase, the floor, the wall, the refrigerator, the bed, the dresser, the bathtub, the clothes in your closet—everything is giving off energy in the form of radiation.

What Max Planck found was that thermal radiation occurred in only certain discrete quantities of energy. He suggested that these *quanta* meant something about the structure within atoms, just as Dalton's discovery meant something about the structure of material elements. As a simple metaphor, think of a visitor to New York City from a culture with no money. The visitor might notice that "money" only comes in certain denominations—1 cent, 5 cents, 10 cents, 25 cents, a dollar, 5 dollars, 10 dollars, and so on. There are no 27-cent coins, and no 8-dollar bills. In a similar way, Planck discovered that thermal radiation only occurred in certain denominations of energy. The "quantum" part of quantum physics refers to these quantities of energy—or energy levels—at which an atom could exist. The important fact was not that atoms could exist at these energy levels, but that they could *only* exist at these levels, and not at levels in between. These early quantum physicists understood that this must indicate something about the internal structure of atoms.

By way of example, imagine a clothes dryer of the type that has fins inside to keep the clothes tumbling as the drum turns. If you did not know its internal design, threw a penny inside and then turned the drum slowly, you might notice that every time the drum rotated one full cycle, you heard the penny inside drop three times. You would be able to guess that this was telling you something about the internal structure of the dryer. In a similar way, early quantum physicists guessed that atoms could only exist in certain energy states because of their structure. Quantum physics, then, was the physics that tried to understand why atoms could only exist in these certain energy states—that is, could only give off these particular quantities of energy and not others.

So far, not much about quantum physics seems related to consciousness. This is because at its core, quantum physics consists of mathematical equations that describe the nature and actions of the tiny bits that make up atoms. Books by physicists that link quantum phenomena with consciousness are not authored by physicists writing as scientists, but by *physicists writing as philosophers*, who are using particular *interpretations* of quantum equations to construct a narrative about reality and consciousness.

Interpretations can help visualize processes that cannot be directly experienced, which may make it easier to understand these phenomena or guide intuition toward new ways of thinking about them (Sanders et al., 2008). But quantum physics would be no less successful at measuring or predicting subatomic events if these interpretations were eliminated entirely. Interpretations are not themselves part of the mathematical equations or the related scientific data; they are for the benefit of physicists, to make it easier for their human minds—and ours—to relate to highly abstract concepts and data.

In the case of quantum physics, the known facts are measurements and sets of equations that describe subatomic processes; interpretations are efforts to make that abstract information comprehensible to humans who are many trillions of times larger than an atom. The key question is whether the general framework of physics that applies to the objects we relate to in daily life—classical mechanics—can be used explain what happens at this infinitesimally small level of the world, or whether the substrate of our apparently mundane world is actually mysterious—whether it reflects a whole new order of reality that may even somehow respond to consciousness, be conscious, or make consciousness possible.

It was physicists of the early 20th century such as Erwin Schrödinger and Louis de Broglie who, having helped create the mathematical formalisms of quantum mechanics, pressed for a way to translate these into something that could be imagined in time and space, the same way that one might imagine the physics associated with a moving baseball or asteroid; others, such as Werner Heisenberg, did not at first believe anything was needed beyond the equations at the heart of quantum mechanics (Bacciagaluppi & Valentini, 2009; Jähnert, 2011). The question of how to visualize these processes was taken up at a famous 1927 conference for quantum physicists held in Brussels—a conference known as Solvay V because it was the fifth quantum mechanics conference of a series founded by Belgian industrialist and philanthropist Ernest Solvay (Bohr, 1963; Mehra, 1975).

This conference was quite remarkable in itself: 28 men and one woman, including some of the world's most influential physicists: Albert Einstein, Marie Curie, Max Planck, Hendrik Lorentz, Paul Dirac, Louis de Broglie, Max Born, Niels Bohr, Wolfgang Pauli, Erwin Schrödinger, and Werner Heisenberg, to name some of the more well known participants; more than half of the attendees were or would become Nobel laureates (Levinovitz & Ringertz, 2001).

Going into the conference, there was no doubt about the accuracy of the mathematical models of quantum mechanics—their goal was instead to explain what was going on in more comprensible terms—in part to improve their own understandings, but likely also to obtain more support for their important but rather obscure work. A number of visualized interpretations of quantum mechanics were advanced, but the subsequent discussions made no progress until Werner Heisenberg chose to support the interpretation advanced by Niels Bohr. Bohr and Heisenberg won out and their version became the standard interpretation of quantum mechanics, which it remains to this day.

The Copenhagen interpretation—a name invented much later by Werner Heisenberg for an alleged but questionable consensus among physicists working in Denmark (Bacciagaluppi & Valentini, 2009; Howard, 2004)—does not itself make any claims about consciousness. As noted, it proposes that the tiny bits making up atoms somehow exist in multiple physical states at the same time, and only collapse into one of those states when measured. Another of the interpretations presented at the Solvay V conference was French physicist Louis de Broglie's *pilot wave theory* (Bacciagaluppi & Valentini, 2009). He argued that his version satisfied the requirements of quantum mechanics as adequately as Bohr's, but did not entail any mysterious processes such as the collapse from many states into a single state.

Pilot wave theory differs from Bohr's interpretation in a simple way: instead of a single equation describing the particle and its likely locations as a probability wave—requiring the particle to exist simultaneously in many places and at no particular place—de Broglie's interpretation uses one equation to describe a physical particle, and another to describe a physical wave propagating through space and time that propels the particle (Wolchover, 2014). This simple distinction eliminates any need for baffling alterations of reality at the smallest levels of matter.

But what of Schrödinger's (1935) cat? In this thought experiment, a cat is put into a windowless box with a vial of poison (hydrocyanic acid) that is controlled by a switch that either does or does not open the vial, based on random events of radioactive decay. At any given point in time, it is of course impossible to know whether the cat inside the cage is dead or whether it is alive, unless one looks. But Scrödinger's metaphor goes further than this. It claims that so long as one does not look, the cat is simultaneously dead and alive, but once one looks, then the act of looking causes the cat to transform from being simultaneously *dead and alive*, to being either *dead or alive*.

Schrödinger's (1935) example has been used to illustrate that observation is what causes the probabilities of quantum indeterminacy to collapse into a specific actuality, a view that has been taken as evidence that consciousness shapes reality. While it serves as an effective illustration, the original intent of this cat scenario was something quite different than its common application to conscousness. Schrödinger developed this description, not to show how remarkable the quantum world is, but to poke fun at the Bohr-Heisenberg interpretation by illustrating what he saw as the absurdity of its implications—he labelled it an example of a "ridiculous" case (Schrödinger, 1980).

While it does not demonstrate the power of consciousness to resolve quantum indeterminacies, the cat paradox does illustrate how foreshadowings may emerge unintentionally within creative works such as metaphor. Schrödinger wrote the paper containing his famed paradox from within a German nation already under the sway of Adolf Hitler, and within a few short years hydrocyanic acid in the form of Zyklon B (Heerdt, 1924)—commonly used in agriculture for fumigation of insect pests (Kaiser, 1927)—would be used to exterminate Jews, Gypsies, Slavs, political prisoners, the handicapped, and homosexuals, who found themselves herded into windowless containment much like Schrödinger's unfortunate feline. The imprisoned cat was an unbidden portent of far darker events in Germany's near future.

As noted, a crucial questions at stake is whether the mathematical formalisms of quantum mechanics require a model that is at odds with the classical mechanics of the everyday world—for if it does, then there is no point in questioning the evidence. However, the Copenhagen interpretation is only one of more than a dozen serious efforts at interpretation, some of which are consistent with classical mechanics. Bohr's proposal was initially supported by only a small minority of the 29 eminent physicists present at Solvay V, and Bohr could not agree even with Heisenberg, his strongest supporter, on the details of this interpretation. Even though the Copenhagen interpretation has propelled quantum physics into the cultural limelight, it is fair to say that its supremacy may owe more to scholarly politics than to science.

Recent landmark research supports the likelihood that Bohr's indeterminacy is at least incomplete. In one experiment, the "quantum jump" of an atom from one energy level to another—which Bohr believed to be discontinuous, indeterminate, and not subject to prediction—was shown to be a partially predictable, continuous process that can be halted and even reversed prior to completion (Minev et al., 2019); this would not be possible unless quantum jumps were deterministic. If replicated, the significance of this work for quantum mechanics cannot be understated, for it would provide a strong challenge to the versions of nonlocality and indeterminism that are central to Bohr's contributions to the Copenhagen interpretation. If true, it may turn out that the indeterminacy of quantum mechanics is located in the minds of physicists rather than in the structure of subatomic particles (Tyler, 2015).

In addition, a series of contemporary experiments has shown that a process analogous to de Broglie's pilot wave interpretation of quantum mechanics can be demonstrated to occur macroscopically in the fluid mechanics of a droplet bouncing across the surface of a vibrating pan of oil; the oil droplet, propelled by a pilot wave created by its own ripples, can be guided through a double slit apparatus with the result that the droplet passes through just one slit, while the pilot wave passes through both slits, creating an interference pattern with itself (Vervoort & Gingras, 2015). The fact that this sort of phenomenon can be demonstrated empirically in fluid dynamics within a macroscopic environment shows that the sort of process proposed by de Broglie is physically possible—which may offer an additional boost to his pilot wave theory. If also applicable to subatomic processes, this would accord with a view that the mechanics of the quantum world may be more similar to the classical mechanics the world of ordinary objects than the Copenhagen interpretation imagines—it may be that Einstein and Schrödinger have the last laugh after all.

This is not to deny the potential relevance of some aspects of physics for theories of consciousness. Radin (2009) has suggested that quantum entanglement may account for the apparent interconnectedness of minds over small and great distances. A recent study has findings that may point towards an even simpler possibility: that electromagnetism may be a property of spacetime itself, rather than an added phenomenon that travels through spacetime (Lindgren & Liukkonen, 2021). There are early versions of schemas suggesting that mind may be in some way linked with the brain's electromagnetic field (McFadden, 2002), which if true might suggest that the connections between minds, and with the living processes of nature, could possibly be by means of the fabric of spacetime itself.

Such ideas are as yet little more than speculations—yet speculations can be valuable ways to imagine one's way towards future research. The study of consciousness—states of awareness and stances of attention—is a worthy project that will continue to develop and grow in multiple directions, sometimes informed by what began as speculations. At the same time, these exercises of imagination deserve to be grounded in notions that are themselves as sound as possible.

In This Issue

The issue begins with Harry T. Hunt's fifth paper in his important Intimations of a Spiritual New Age series. These papers consider foundational thinkers of the 20th century who revitalized spirituality in a post-modern context in ways that prefigured or anticipated a spiritual New Age; the current entry, titled Carl Jung's Archetypal Imagination as Futural Planetary Neo-Shamanism, situates C. G. Jung's neo-shamanistic worldview within a cognitive-developmental model of affect. Hunt notes that Piaget did not believe a formal operations stage was feasible in affect, then argues that such a development may in fact be initiated through numinous experience. Hunt holds this schema of affect to be inclusive of a spiritual or transpersonal intelligence, and characterizes Jung's experiential mysticism, along with his active imagination, archetypes, and mythic amplification, as directly related to Jung's notion of a generative shamanistic current of human experience. Hunt is careful to make the case that Jung's conceptualization of spiritual intelligence does not reveal a soft perennialist transcendent ultimate, but rather an implicit capacity for metaphoricity that makes sense of the situatedness of mind and world. Jung, along with other thinkers considered in this series, took up the renewal of sacred meaning and purpose in human psychological and spiritual life through experiential practice and spontaneous engagement with the world at large–and Hunt's paper brings forward original insights on Jung's contributions toward this end.

Sasha Strong's paper, titled Diverse Mindfulness Practices for Bipolar Recovery: Qualitative Study Results, presents findings from a thematic analysis of interviews with nine participants on the impact of Buddhist-informed mindfulness practice in recovery from bipolar disorder. Strong argues that mindfulness based interventions typically decontextualize mindfulness practices from Buddhist conceptual frameworks that may have therapeutic value, and that may support self-management. This research adds to the sparse but valuable literature supporting the potential efficacy of such practices in BD recovery, while also suggesting that pathways to healing are idiosyncractic.

The final paper, by Genine P. Smith and Glenn Hartelius, is entitled Mindfulness Based Intervention for Needle Phobia: A Pilot Study of Dissociated Ego State Resolution. This study reports on work with six participants with a mindfulness-based intervention for needle phobia using a process designed to resolve a dissociated ego state. Though the sample size was small, the results are promising given that substantial and statistically significant reductions in levels of distress were reported post-test, and distress levels at 3-month and 6-month follow ups were further reduced as compared with post-test. The second author recused himself from the journal's evaluation of this paper since he is also an editor of this journal.

These papers provide welcome additions to the transpersonal literature, and we hope you will find them both enriching and useful in stimulating further research.

Glenn Hartelius, Main Editor
Courtenay Richards Crouch, Editor

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About the Journal

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