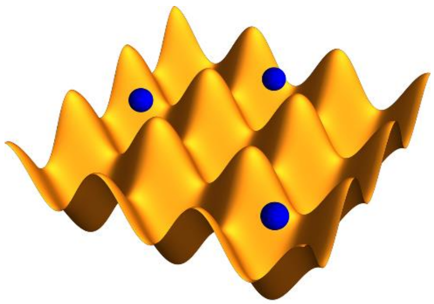

# Quantum Physics

***Some Key Aspects***

By Albert Fried-Cassorla

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A very succinct summary of Quantum Physics appears in Wikipedia: "Quantum mechanics is the study of very small things." Indeed, quantum mechanics was developed to study the atomic level, which is on the nanoscale or smaller. (The term "very small" refers to such entities as electrons, positrons, and quarks, which are all considered point particles.) Nonetheless, quantum effects bears on many large systems as well, under extreme circumstances, from superfluids to superconductors..

So, why try to get a grasp of this often-enigmatic field? Because understanding the physical universe is part of what we do every day as humans. And it should be the mission of anyone who claims to have an interest in Philosophy.

As an amateur with only a tenuous grasp of the subject matter, I have been trying to identify the main principles of Quantum Physics, and, what might be the main sources of confusion about them. Hence, this article.

## Wave Function

One of the most perplexing but critically important aspects of Quantum Physics is the Wave Function. It is also written as one word: wavefunction.

Understanding it is perhaps the essence of the field itself.

As Paul Halpern says, referring to quantum pioneer Max Born, "The wave function would possess no physical characteristics if its own - neither energy nor momentum." (Halpern, p. 99)

To my mind the concept of a wave function is similar in some respects to that of a point in the physical universe, yet it can be spread out in an abstract space. That is, a point is a referred-to place that can be identified via coordinates. However, it does not exist physically except via that definition.

One way of thinking of a wave function is that it represents a probability distribution – a measure of the chance that a particle possesses a certain value of a physical parameter. It is a bit like a curve showing the typical grade distribution of a class. Therefore, if you identify a student in that class, without specifying anything else about them, you would know the odds that they got an A, B, or C.

A **"wave function collapse"** is a measured event. Once a certain property of an object is observed or measured, its wave function suddenly homes in on one of the values of that property by contracting into a tighter distribution. Expressed differently, by me: "a wavefunction collapse is a mathematical expression of a particle or energy moment at a particular time." However, what is measured is not, say, at X, Y and Z coordinates precisely. Instead, it is at a *range* in that approximate area. The probability of having a certain value is referred to by physicists as their *amplitudes*. (The squaring is done to yield a positive probability value)

A wavefunction, therefore, refers to a "snapshot" of an event that did happen at a particular time and place. Again, "particular" as used here means in a range of possibilities. It has characteristics of both a particle and a wave. The term "snapshot" is my own, but I think it fits.

The Wikipedia definition of a wave function is this:

> "A **wave function** in quantum physics is a mathematical description of the quantum state of an isolated quantum system. The wave function is a complex-valued probability amplitude, and the probabilities for the possible results of measurements made on the system can be derived from it." [i]

## Wave-Particle Duality

One basic concept of Quantum Physics is the notion of wave-particle duality. That is, that electrons and other sub-microscopic items have characteristics of both particles and waves. In the wave function article in Wikipedia, there is a good graphic representation of the differences between classical physics and quantum physics on this. [ii]

Interestingly, these objects or events cannot simultaneously be described in terms of waves or particles. They may be described as one or the other. On the other hand, the events themselves exist simultaneously as both. Only the descriptions are mutually exclusive.

## Heisenberg Uncertainty Principle

Physicist Werner Heisenberg enunciated his famous principle, which means in essence that an event or objects cannot be said to be in a certain time and place with absolute precision while at the same time its energy and momentum are known with absolute precision. There is a built in "fuzziness" on a fundamental level. It can only be in a range of times and places, and no formula can say what where it is exactly in space-time, or predict its location and momentum precisely. This I not contradicted by that I wrote earlier about "snapshots."

## Probability Amplitudes

Since Quantum Physics deals in probabilities, not exactitudes, the notion of Probability Amplitudes seems fuzzy compared to classical physics. But the range of probabilities gives a fairly precise measure of where in time and motion a given event would exist, or would have existed.

**Spin** - Physicists speak of electrons having either up or down spin. The spin is not visible in any sense, or actually spinning. But electrons *behave* as though they are spinning. According to the Pauli Principle, entangled electrons may not be exactly the same, in terms of their spin or charge. If one has a spin pointing on its axis up, the other must point down.

When two electrons are entangled, one electron "knows" the spin state if the other – even across large distances. We are told by physicists that no real information passes between the electrons, yet somehow, they "know." To me this process is mysterious.

Honestly, I do not see how it is possible. Yet scientists agree that this is what is happening. This phenomenon is also called "spooky action at a distance." He said that "quantum mechanics should allow two objects to affect each other's behavior instantly across vast distances." [iii] This is something Einstein called "spooky action at a distance"1.

An experiment in the Netherlands apparently confirmed this.[iv] That article in the journal ***Nature*** speaks of "hidden variables," which themselves are hard to understand. John Bell's theorem shows that there are no hidden variables, meaning that this entanglement really happens. This notion of spooky action vexed Albert Einstein.

## Schrodinger's Cat Experiment

This proposed situation (not a real experiment) supposes that a cat is in a box, within which a hammer exists that will destroy a container and release deadly radiation. The "sample" would kill the cat. If the hammer does not release the poison, the cat would live. But we do not know its status until we open the box. So, the cat is in a suspended state involving "superposition."

Some scientists posit that the cat exists in multiple states in multiple universes.

## "How the Universe is Connected"

This simple phrase above encapsulates so much.

That is, the many ways in which we understand what is happening in a multitude of processes can be subdivided and categorized. Each form of connection is different and constitutes a primary circumstance of how the universe works and how we understand it.

This 5-word above phrase and much of what follows is based on Dr. Paul Halpern's presentation to the Melrose Park Philosophy Club on June 5, 2021. [v]
(See https://www.youtube.com/watch?v=yED_hnQT220 )

The five forms of connection that Dr. Halpern develops are:

1. **Cause and Effect** – An example would be a billiard ball hitting another ball and causing the second ball to move. Here, the cause and effect principle is obvious to most people. However, ever since David Hume wrote on the topic, it has been the subject of debate. [vi]

2. **Correlation** – Examples are lightning occurring and overflowing gutters. We know that they often happen at the same time but also that they are not causally related.

3. **Coincidence** – This may be described as: "Concurrent events that have no apparent causal connection with one another."[vii]

4. **Sheer Chance** – We can call this an event with no causality, and no apparent correlation.

5. **Quantum Entanglement** - An electron's spin is very important in understanding quantum entanglement, wherein one electronics spin affects another's in an opposite way. That is, suppose that Electron A and Electron B are entangled. Then if electron A's spin is up, Electron's B's spin will be down — even if electron B is at the far end of the universe. Quantum Entanglement has been demonstrated photographically. [viii]

## Final Thoughts

I cannot call this a conclusion, since this brief essay leaves so much unsaid. Quantum physics is a very lively field in physics and has changed computer science, electronics, and much more. Rather than having "explained" Quantum Physics, I hope I have outlined some of its key aspects.

I wish to offer special thanks to Dr. Paul Halpern, who visited our club and provided much of the inspiration and content for this article. He also helped edit and refine this essay. His 17 books, including *Einstein's Dice and Schrodingers' Cat* are available wherever books are sold.

### About me:

I am a teacher, writer, poet and playwright, among other things! I also have led the Melrose Park Philosophy Club, which I co-founded in 2001 approximately. We have had many meetings on diverse topics on that time. For some of these see, www.fried-cas.com/philosophy

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[i] https://en.wikipedia.org/wiki/Wave_function
[ii] https://en.wikipedia.org/wiki/Wave_function
[iii] https://www.nature.com/articles/d41586-020-00120-6
[iv] https://www.nature.com/articles/nature.2015.18255
[v] https://www.youtube.com/watch?v=yED_hnQT220
[vi] https://en.wikipedia.org/wiki/Causality
[vii] https://en.wikipedia.org/wiki/Coincidence
[viii] https://www.extremetech.com/extreme/295013-scientists-capture-photographic-proof-of-quantum-entanglement

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