QUANTUM MECHANICS FOR THE COMMON MAN

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Abstract

The overriding problem in theoretical physics is the inability to determine the nature of physical reality [1]. We show in the following discussion that the source of the problem lies at the very beginning of quantum mechanics a hundred years ago when its founding principles were derived. The use of mathematical equations as a substitute for physical reality caused a premature, hastily conceived disassociation from classical models. Using methods accessible to all, irrespective of educational background, we restore a connection to classical physics by demonstrating that quantum mechanics as currently interpreted violates the conservation of energy. References may be found in first year university physics textbooks or by conducting internet searches of individual terms throughout the manuscript.

Quantum physics is a fascinating subject not only because it concerns nature at its most fundamental level but it is also pivotal in the development of new ideas and practical applications. It would be much more interesting if we could understand it better. The reason we can't is that the microscopic world behaves much differently from the world around us and it is not clear how the two are connected. Is the quantum world truly different or does it require a stretch of the imagination that we as mere mortals are not capable of? Differences of opinion and confusion concerning this question are exploited by experts who attempt to obtain credibility for their theories by claiming that a phenomenon is "quantum". Nobel prize winner and quantum theoretician Roger Penrose is currently investigating whether there is a connection between wave function collapse and consciousness [2]. He has not cited experimental evidence other than to express a strong belief of its likelihood. In normal circumstances presenting an idea without evidence is speculative, but no one is claiming that because he might be right. The lack of a clear physical interpretation of the "quantum world" means that, whether intentional or not, a cloak of mystery surrounds everything about it. The 2022 Nobel prize for physics was awarded for the experimental proof of faster than light communication by means of entanglement, but the fact that it was experimentally proven does not make it easier to understand. Quantum mechanics is the most accurately verified theory in the history of science and its predictions have never been known to fail, but alternative physical models are still sought after for the express purpose of improving our understanding.

Many different interpretations of quantum mechanics exist, but none seriously proposes altering the mathematical formalism which is ingrained in its many practical applications and is used every day to calculate problems in atomic physics as an integral part of the Standard Model. There is nevertheless a long-standing desire to understand the underlying meaning of the formalism. To analyze the physical basis of the mathematics we shall review the original paths of derivation taken a century ago. Matrix mechanics, introduced by Heisenberg in 1925, is based on hydrogen's emission spectrum and uses matrices to describe how the properties of observables, the frequency and intensity of the spectral lines, are related to electron energy transitions. Wave mechanics, derived by Schrödinger the following year, is based on the fact that matter has an associated wave and it may be used to predict an atom's bound energy states and the frequencies of the spectral lines. The theories obtain the same experimentally observed results, the spectroscopic lines of hydrogen, but they do so in very different ways; that is, their experiments, mathematical formalisms, and physical interpretations are completely different. Nature is known for efficiency of expression and minimalism so it was questioned why two mathematical formulations exist when a single theory was expected. Wave mechanics is more easily visualized and more useful in calculating many of the properties of hydrogen's electron orbitals so it soon became the overwhelmingly preferred model. The second model, matrix mechanics, uses a more obscure mathematical formalism that seemed difficult to interpret physically and it is of limited use in making experimental predictions. We are more familiar with its role in the derivation of the uncertainty principle than in its experimental applications. The two models were proven mathematically equivalent but wave mechanics was favored because of its links to causality via the Born rule and its visualizability.

Matrix mechanics' connection to reality was never questioned because the physical significance of matrices and matrix elements is well known. The diagonal elements of the matrix designate the observed spectral lines while the non-diagonal elements are unobserved exchanges of energy. Heisenberg arbitrarily assigned them a value of zero because he believed that "only what is observable" should be included in quantum theory. It is common practice in the construction of mathematical models to make approximations. There is not a single theory of nature, especially experimentally derived theories, that pretends to describe nature exactly. For that reason no one questioned why Heisenberg did not take into account the unobserved energy and momentum transfers of molecules that are represented by far from diagonal electron transitions. He reasoned correctly that individual molecular impulses do not contribute substantially to the observed spectral lines, and he also dismissed them because they are unobservable. What he did not take into account was that the infinitesimal contributions extend to infinity and when integrated over the entire space of the atom they combine to represent the molecular impulses of thermal energy which lead up to and produce the spectral lines. Heat is unobservable at the microscopic level in terms of molecular impulses but when the innumerable energy exchanges are summed we observe them as temperature. Without heat there is no black body radiation and no experimental results to observe. An atom in Heisenberg's theory that is described by a matrix with non-diagonal elements equal to zero would be immersed in a "thermal bath" of absolute zero and would not radiate at all. Disregarding how atoms absorb energy is to ignore one-half of radiation processes and one-half of quantum mechanics.

It is now possible to appreciate the reason for quantum mechanics having two distinct mathematical formalisms, one based on matrices and the other on wave functions. They both describe the same invariant physical observables that characterize the steady states, but the mathematical formalisms are different because the former refers to absorption and the latter to emission. Due to the conservation of energy, absorption as described by matrices, must be carried out to completion before emission, as described by the wave function, can begin. To satisfy the conservation laws we must describe the complete radiation process by a *transformation of energy*. Absorption and emission are equally important because neither one can occur without the other. Energy is first absorbed raising the electron to a higher state, and it then decays by emitting a photon. To describe energy emission without first describing how energy is absorbed violates energy conservation because it suggests that energy was created. The atom is a closed system so for energy to be extracted from it an equal amount must be put in. Simply stated, quantum mechanics describes how the atom transforms thermal energy into quantized energy.

The Schrödinger equation uses the wave function to describe the dynamics of quantum mechanical systems such as hydrogen. However it cannot be assigned independent reality because it violates the conservation of energy. In classical terms the wave function may be compared to a hydroelectric plant with an empty reservoir. It must wait for energy to be absorbed by the reservoir before its actions can be observed. Quantum mechanics is primarily a theory of observables rather than energy, so it was a natural step to extend the boundary conditions of wave functions outside of the atom to describe scattering. Extending boundaries to infinity allowed the entire universe to be described by a wave function. Expansions of the time dimension made it possible to conceive of "parallel" universes. Each time the boundary conditions were generalized to allow greater flexibility the wave function became further removed from physical reality.

How is it possible for so many people to take the wrong path and continue on it for so long? Richard Feynman answered that question in a 1974 speech at Caltech. He told the recent graduates that in their future careers of science, "The first principle is that you must not fool yourself, and you are the easiest person to fool." Nature did not trick us by requiring two mathematical formulations to describe the emission and absorption of radiation. The founders of quantum mechanics tricked themselves into thinking that one formulation was enough.

References

[1] https://www.youtube.com/watch?v=Wsjgtp9XZxo
[2] https://www.youtube.com/watch?v=0nOtLj8UYCw