



Reality is referred to more than one hundred times in this book. And I expect that many readers will ask what I understand reality to be, especially in view of the strange reality of quantum mechanics. Long-held opinions about material reality were challenged in 1801 when light (photons) was used in double-slit experiments. In those experiments, photons passed through double slits and then onto a screen. If light consisted of particles, as Isaac Newton thought, photons would pass through the slits and form predictable particle-like patterns on the screen. What actually appeared on the screen was a double-slit interference pattern of bright and dark bands characteristic of waves, not particles. The bright bands were constructive interference regions where photons would most likely appear on the screen. Since this early experiment, electrons, neutrons and collections of hundreds of atoms were passed through double-slits and produced similar interference patterns. In addition, it was found that an interference pattern appeared even when a single photon passed through a single slit. The challenge these experiments pose for a traditional, material-based view of reality is if particles can behave as both particles and waves, is a traditional view of a material reality wrong?

Quantum mechanics can represent the location of a particle, such as a photon, as a mathematical expression called a wave function. Such wave functions can indicate the probable positions of particles in double-slit interference patterns. However, quantum mechanics cannot yet explain why the wave and particle states of photons behave as they do. Thus, it is left for us to propose interpretations of such behavior. Numerous concepts have been suggested, two of which can be described briefly as follows. The first posits that the location of particles on double-slit screens is probabilistic, that the particles follow no particular path to the diffraction pattern screen and that the particles transition from non-real waves to real particles when the wave function "collapses," which is thought to be initiated by measurement, observation, or some form of consciousness. The second posits that the position of a particle is determined by interacting with an associated "pilot wave" and that particles travel in one path from a slit to the interference pattern screen. In this theory, the pilot wave passes through both slits, which introduces an interference pattern as it interacts with its associated particle that traveled through one slit. The particle's path is determined by its prior position and velocity. In this "pilot wave" model, the particle's ultimate path and position are deterministic. The pilot wave model doesn't involve real particles with "non-real" waves or the need for wave function collapse to materialize the particle. However, knowing the exact position and velocity of a quantum particle is problematic for the pilot wave conjecture. Both of these proposed models have unresolved issues. One other popular interpretation is called "many worlds," which we won't go into here, and there are many other less popular interpretations that have not yet gained much traction.

Where does that leave our understanding of reality? Until now, what we know about the nature of things has been learned by using the scientific method of analysis. Our progress as humans, to a great extent, is the result of scientific discoveries about the nature of reality. Those discoveries,

instead of arriving fully formed, have been refined over time as more is learned about Nature. In one example, Newton's laws of mechanics were modified by Einstein's theory of relativity. Will the mysterious nature of quantum mechanics follow this pattern? Perhaps the reality our ancestors experienced as their DNA was being refined involved no significant relativistic and quantum mechanical effects. While we now know that time passes more slowly for an eagle diving to seize a sloth, that fact appears to have little or no influence on the genetic evolution of eagles and sloths.

Until the first double-slit experiment we believed that $A + B$ equals $B + A$. We now know that at the quantum mechanical level $A + B$ need not equal $B + A$. While quantum mechanics has changed our commutative view of reality, to date no experiment has given us a reality model that replaces the utility of our pre-double slit view. I look forward to the experiment that results in a new reality model that explains the quantum effects we observe and why we need not discard technology developed using a deterministic view of reality.

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