

The Dual Nature of the Electron

Based in Classical Electrodynamics

Confirmed by the Electron Double-Slit Experiments

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Abstract. In the quantum theory of wave-particle duality, a wave changes into a particle at the moment of an “observation” or a “measurement.” In the spinning charged ring (SCR) model, an electron is *simultaneously* a wave and an elastic, finite-sized particle. Contrary to Feynman’s conjecture, the experimental results of the double-slit interferometer experiment can be explained in a classical way. The electron is a classical electromagnetic object, not a quantum object. The double-slit experiment (and its variations), conducted with individual particles, has become a classic thought experiment for its clarity in expressing the central puzzles of quantum mechanics because it supposedly demonstrates the fundamental limitation of the ability of the observer to predict experimental results. Richard Feynman [1] called it “a phenomenon which is impossible...to explain in any classical way, and has in it the heart of quantum mechanics.” However, a classical explanation follows below.

Introduction. The Standard Model of Elementary Particles describes an electron as a wave that, when observed or measured, *changes* into a point-particle with four empirically-measurable fundamental properties: electric charge, mass, angular momentum (spin), and magnetic moment. This change or collapse, from a wave composed of oscillating electric and magnetic fields into a point-particle, is called ‘wave-particle duality.’

The new spinning charged ring (SCR) model of the electron is a finite-sized elastic ring that accounts for the particle and wave features in a fundamentally different way.

THE ELECTRON ACCORDING TO THE SPINNING CHARGED RING MODEL [2, 3]

After many years of observations, experiments, development of physical theory, application of technology, and manufacture of electrical and electronic devices of all sorts, physicists and chemists have compiled a great amount of evidence supported by physical theory and the laws of electromagnetics which show that *the electron is composed of one unit of a material substance called ‘electrostatic charge.’*

Moreover, this ‘charge’ is the source and cause of a surrounding electrostatic field composed only of pure electric energy (no charge being present). And the *rotating motion* of this same ‘charge’ is the source and cause of a surrounding magnetostatic field composed only of pure magnetic energy (no charge being present). *Thus, the electron consists of both charge and electromagnetic fields, each having its own structure, which taken together define the electron and its dual nature.*

Electron Waves. According to the Spinning Charged Ring [SCR] model, electromagnetic fields composed of static or oscillating fields (waves) and electric charge *can and do exist at the same time*. Thus the waves of a single electron will pass through both slits of a double-slit interferometer and produce a wave interference pattern of bright lines on the interferometer screen.

Structure of the Electron and its Two Electromagnetic Fields. Just as ordinary objects are composed of a material substance with size and shape, so also by the principle of unity, the philosophy of structuralism, and the established laws of electromagnetics must an electron be composed of a material substance with size and a specific shape. Figure 1 shows a portion of the electrostatic energy field, and Figure 2 shows a portion of the magnetostatic energy field.

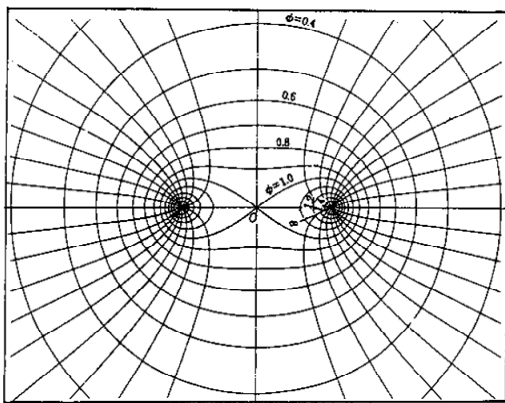


Figure 1

Electric Field and Force Lines outside a spinning charged ring. Inside electric field is **not** shown.

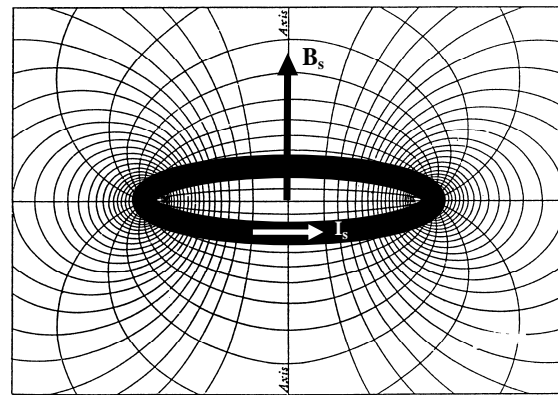


Figure 2.

Magnetic B_{so} -Field outside a current loop. Directions of the spinning current I_s and the B_{so} field are shown. Inside Magnetic field is **not** shown.

THE ELECTRON ACCORDING TO QUANTUM MECHANICS

Particle Nature of the Quantum Electron. The point-electron is still a dominant feature of the Standard Model of the electron. In 1990, the Nobel Prize for physics was awarded to Hans Dehmelt [4, p. 539], who wrote about the “structure-less point-particle predicted by the Dirac theory.”

Physically, an elementary particle is regarded as a stable, point-like, structure-less entity (structure-less except for having mass, spin and other possible quantum numbers), which in its free state moves on a world line with momentum k [5].

The point-electron model used for convenience has additional problems of structure called a “mystery” by Sellin:

A good theory of electron structure still is lacking.... There is still no generally accepted explanation for why electrons do not explode under the tremendous Coulomb repulsion forces in an object of small size. Estimates of the amount of energy required to 'assemble' an electron are very large indeed. Electron structure is an unsolved mystery, but so is the structure of most other elementary objects in nature, such as protons [and] neutrons [6].

Assumed Properties of a Quantum Electron. Since the quantum electron has no physical structure, and no mechanism exists for exchanging energy or transmitting forces, then it is necessary to assume four fundamental properties for the electron. Quantum theory assumes that electrons have intrinsic properties of spin, magnetic moment, charge, and inertial mass. The theory makes no attempt to derive them or relate them to a physical structure, but chooses such models that cannot relate its features: a point model is chosen for some occasions, and a wave model is chosen on others.

Wave-Particle Duality According to Quantum Mechanics. Several experiments show empirically that the electron must be a small but finite-size *particle*. Other experiments provide equally compelling evidence that the electron must be an electromagnetic *wave*. Nick Herbert notes this dichotomy:

An electron seems to possess contradictory attributes. As a particle, it must be localized in space, and retain its identity in collision with other particles. As a wave, it spreads over vast regions of space and merges completely with other waves it happens to meet [7].

Quantum physicists point to the Double-Slit experiment for evidence of *wave-particle duality*, and describe the quantum mechanics model of the electron as a wave that changes into a particle.

Wave-particle duality is deeply embedded into the foundations of quantum mechanics, so well that modern practitioners rarely discuss it as such. In the formalism of the theory, all the information about a particle is encoded in its wave function, a complex-valued function roughly analogous to the amplitude of a wave at each point in space. This function evolves according to a differential equation (generically called the Schrödinger equation), and this equation has solutions that follow the form of the wave equation. Propagation of such waves leads to wave-like phenomena such as interference and diffraction [8].

The particle-like behavior is most evident due to phenomena associated with measurement in quantum mechanics. When viewed through this formalism, the measurement of the wave function will *randomly* "collapse", or rather "decohere", to a sharply peaked function at some location. The likelihood of detecting the particle at any particular location is equal to the squared amplitude of the wave function there. The measurement will return a well-defined position, (subject to uncertainty), a property traditionally associated with particles [8].

Twentieth Century Crisis in Particle Physics Regarding the Nature of Electrons.

In the quantum theory of wave-particle duality, *a wave changes into a particle* at the time of an “observation” or a “measurement.” Somehow, the specimen object, a photon or an electron supposedly has prior knowledge of its quantum state, as a particle or a wave, before being detected on the screen of a double-slit experiment:

The far-reaching conclusion of this experiment is that some form of communication is occurring within the light wave [photon or electron] informing it is, or is not, appropriate to land on the screen [9, p.33].

A strange and inexplicable principle of quantum mechanics is the Bohr Complimentary Principle which states roughly that *the particle and wave aspects of quantum objects cannot be observed at the same time.*

However, *in the SCR model, the electron is both a wave and a particle at the same time.* Contrary to Feynman’s conjecture, the experimental results of the double-slit interferometer experiment can be explained in a classical way. The electron is a classical electromagnetic object, not a quantum object.

Gauss’s classical law of electric fields recognizes that the distribution of charge inside the electron establishes a corresponding electric field outside its ring-shaped boundary of charge. Likewise, the current in the charged ring establishes a surrounding magnetic field. Thus, the electron’s particle state is communicated constantly at the speed of light to the surrounding and expanding electromagnetic fields. The electron wave is a part of every electron for all time, and there is no mystery of why the interference pattern develops on the screen from waves of one electron that pass through both slits to create an interference pattern on the screen!

THE DOUBLE-SLIT EXPERIMENT

Wave Detection. The double-slit experiment detects waves of electromagnetic radiation:

This experiment is sometimes referred to as Young’s experiment. The experiment belongs to a general class of “double path” experiments, in which a wave is split into two separate waves that later combine back into a single wave. Changes in the path lengths of both waves result in a phase shift, creating an interference pattern [10].

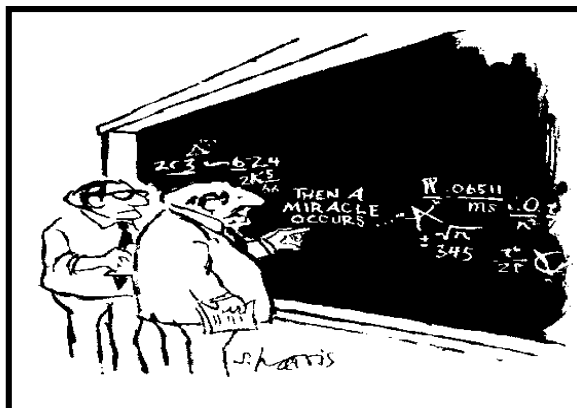


Figure 3. Then a miracle occurs.

“I think you should be more specific here.”

Permission to use obtained.

In the basic version of this experiment, a coherent light source such as a laser beam illuminates a plate pierced by two parallel slits, and the light passing through the slits is observed on a screen behind the plate. The wave nature of light causes the light waves passing through the two slits to interfere, producing bright and dark bands on the screen—a result that would not be expected if light consisted of classical particles. However, the light is always found to be absorbed at the screen at discrete points, as individual particles (not waves), the interference pattern appearing via the varying density of these particle hits on the screen [10].

The double-slit experiment (and its variations), conducted with individual particles, has become a classic thought experiment for its clarity in expressing the central puzzles of quantum mechanics because it demonstrates the fundamental limitation of the ability of the observer to predict experimental results. Richard Feynman called it “*a phenomenon which is impossible...to explain in any classical way, and has in it the heart of quantum mechanics.*”[1].

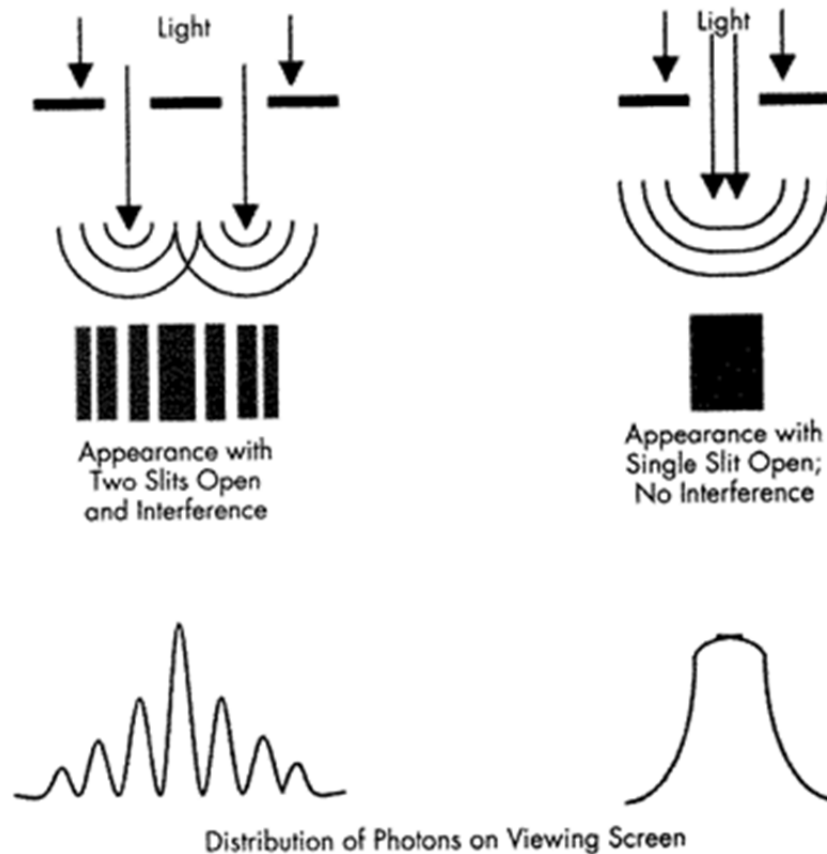


Figure 4. The Double-Slit Experiment [9]

But the new classical spinning charge ring model [2, 3] is shown here to explain ‘wave-particle duality and predict the experimental results of the electron double-slit experiment.

Photons and the Photoelectric Effect. Prior to 1905, Thomas Young had shown that light demonstrated the properties of waves. However in 1905,

Einstein demonstrated that light had properties characteristic of particles as well as waves, a discovery (the photoelectric effect) for which he later received the Nobel Prize. Since that time, this dual nature, inherent in light, has become known as the “wave-particle duality. A *single photon* is defined as a discrete unit of electromagnetic radiation, and as such may be identified as either a particle or a wave, or both [9, p.31].

ONE VARIATION OF THE DOUBLE-SLIT EXPERIMENT. ELECTRON BUILDUP OVER TIME

Interference of Individual Particles. An important version of the double-slit experiment involves single particles.... Sending particles (electrons) through a double-slit apparatus one at a time results in single particles appearing on the screen, as expected. Remarkably, however, an interference pattern emerges when these particles are allowed to build up one by one.... This demonstrates wave-particle duality which states that all matter exhibits both wave and particle properties.... [8].

Conclusions.

1. Contrary to Feynman’s conjecture, the experimental results of the double-slit interferometer experiment are explained here in a classical way [2].
2. In the SCR model, the electron is both a wave and a particle at the same time. In the Standard model, the electron is first a wave that, when observed, changes into a particle without any credible process for the exchange of energy.
3. Both models (the Standard model and the SCR model) are associated with the four fundamental properties of the electron.
4. In the SCR model, causality and ‘conservation of mass and energy’ rule. In the Standard model, the Heisenberg Uncertainty Principle imagines random chance events by means of statistical probabilities.
5. In the Standard model, ‘quantum entanglement’ is treated as a paradox, and logic is not applied to reject conjectures that are found to be in contradiction to first principles.

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