Chapter 1. Introduction

Many generations of scientists had ever heralded that they were the last generation to face the unknown in the world! However, the dreams of one generation after another had not made into anything. Facing the complicated real world, we have to truthfully admit that we almost know nothing about it. Especially, the fundamental problems of quantum mechanics force us further recognize our ignorance. But we cannot hang back in face to difficulties, which is not the nature of human being. The road ahead will be long and our climb will be steep. Truth has no end, exploration is endless. Foundation of Quantum Mechanics in Dual 4-Dimension Spacetime: The Spacetime Origin of Quantum Probability has born pass through the exploration of more than 50 years, which we expect to be a solid step in scientific exploration.

1.1. The Outstanding Fundamental Problems in Quantum Mechanics

1.1.1. Wave-Particle Dualism of Micro-Objects

There were two kinds of different opinions regarding nature of light in the 17 century. One opinion was the corpuscular theory of light, which was proposed by Isaac Newton, a well-known British physicist, who claimed that light is a particle flow that is transmitted in space at a certain speed. Another opinion was the wave theory of light, which was maintained by Christian Huygens, a Holland physicist, who claimed that light is a wave that travels in the ether. In explaining the refraction phenomenon of light from the air into the water, it was confirmed that the speed of light in the water is less than that of the air which further supported for the wave theory of light. In the early of 19th century, both double slit interference experiments and single slit interference experiments found out the undulatory properties of light, such as interference, diffraction, polarization, and so on, which coincide well with the wave theory, but

collide with the corpuscular theory. In 1870s, James Clerk Maxwell proposed the electromagnetic field theory which made the wave description of light to reach the point of perfection. It seemed that the wave theory of light won an overwhelming victory beyond all dispute. However, the situation is much more complex than it seems.

According to wave theory of light, the propagation medium—ether is required to transmit light wave. However, the properties of ether are too monstrous to people eventually have to give up the imagined ether. How to transmit light wave without the propagation medium? The new puzzle rises once again. Moreover, light wave not only is a form of motion that light transmits, but also has light pressure. So light wave shows matter properties. That electromagnetic field has matter property is a strongly demonstration.

Max Planck proposed the energy quantum hypothesis of electromagnetic radiation when he studied the problem of black-body radiation in 1900. Energy quantum has both wave and particle properties. When calculating the absorbed energy or the emitting energy by black-body people (Max Planck?) find that if the energy is deduced from the point of view of particle, one can obtain Wien formula that fits in with short wave; if the energy is deduced from the point of view of classical standing wave, one can obtain Rayleigh-Jeans formula that fits in with middle or long wave. In the end of the nineteenth century the photoelectric effect was discovered, which cannot be explained in terms of classical electromagnetic theory. In 1905 Albert Einstein proposed a light quantum hypothesis that assumes light is made of a particle flow with mass, energy and momentum, which excellently explained the photoelectric effect. In 1916 Albert Einstein proposed a pair of relationship describing wave property of photon: c，$p = h/\lambda$, where E represents the energy of a photon, p represents the momentum of a photon, ν represents light-wave frequency of a photon, λ represents light-wave wavelength of a photon. The relationship shows that a photon is defined by its opposite—wave, vice versa.

In 1924 Louis de Broglie, inspired by Einstein's light quantum/photon idea, proposed the matter wave hypothesis, which suggests entity particles, such as electronic, proton, neutron, atom, and so on, have also wave property. Waves associated with entity particles are named as matter wave. Moreover, he thought the relationships $E = h\nu$, $p = h/\lambda$ fit in with entity particles and calculated the frequencies and wa-

velengths of their matter waves. Soon the wave property of electron is experimentally verified, its frequency and wavelength fit in with the calculations. The prelude regarding the researches of light and wave-particle dualistic of entity particles, as well as the discussions of fundamental problems of quantum mechanics is opened from then on.

1.1.2. The Researches and Discussion of Fundamental Problems in Quantum Mechanics

The wave-particle dualism of microscopic objects makes people believe microscopic objects per se are the coexistence community of wave and particle, which is incompatible with macroscopic classical concepts. In macroscopic classical world, an objective reality is either a particle or a wave, not both. How can microscopic objects have wave-particle dualistic? How are physical model transformation and physical mechanism hidden in the microscopic world? This is a world scientific puzzle. It has taken the scientists that almost one century to try to dissolve the puzzle of wave-particle duality, which is still a dream of their unremitting pursuit now.

In 1926 Erwin Schrodinger obtained a motion equation of matter wave, the Schrodinger equation, when he researched De Broglie matter wave. The solution of the equation—wave function—was called as De Broglie-Schrodinger wave, which soon was regard as the quantum basic entity by the peers. The electromagnetic wave was even also regarded as De Broglie-Schrodinger wave associated with photon. De Broglie initially thought that the particle was riding on a wave, which was called the pilot wave theory. Erwin Schrodinger yet proposed the wave-packet theory, but wave-packet is expanding, which is inconsistent with experiments. So De Broglie-Schrodinger's entities have not been accepted.

Max Born proposed a probability interpretation of matter wave, in which the square modulus of the wave function is the probability of the particle occurring in the unit volume. Subsequently, proton, neutron and atom were proven having wave property, and even grains of sand, stones and all of macro-objects in the whole universe are supposed having wave property. However, we have never observed the wave phenomenon of macro-objects in our real world.

Matter wave is probability wave, isn't it? Probability wave is knowledge wave—mathematics wave, but a mathematics wave cannot produce the real coherence which physical wave can produce through the double silts. Electronic wave can produce the real coherence through the double silts, thus it requires matter wave must be physical wave. In 1952 Bohm proposed a hidden variable theory, which given a realism interpretation of wave function, but it still has not shaken the dominant position of the Copenhagen interpretation. About the understanding of matter wave as probability wave and physical wave, various solutions have been proposed in the last one hundred years. However, so far, satisfying results have not been obtained, and the scientists are still in hard exploration.

An electron appears as a wave when it goes through the double slit, but it appears as a particle when it hits on the screen, and presents probability distribution. How to transform the volatility and the particle in the movement? No answer now! The evolution of the wave function in the Schrodinger equation is deterministic, reversible and coherent, while the distribution of electron hitting on screen is probability, non-deterministic, (its evolution being) irreversible and decoherent. How to originate the probabilistic attributes of the micro-objects? The Copenhagen declared that it is the nature of the micro-object. However, Einstein did not agree with the Copenhagen interpretation, who did not believe that the God plays dice. This is the famous debate between the determinism and the non-determinism in the quantum mechanics. The wave function of the stationary state can decompose into the superposition of eigenstates, and each eigenstate can exist at the same time, which will collapse into one of eigenstates when it is measured. The collapse is mutational and superluminal, which is contradicted against the relativity theory. This is the famous debate between the locality and the non-locality in quantum mechanics. Electron is both the particle and the wave in quantum mechanics, but according to classical mechanics, the wave and particle is not compatible. Does the electron entity exist behind the phenomenon? As a result, the debate between realism and anti-realism also rises in quantum mechanics.

Some philosophers are actively involved in the debate, which is still going on nowadays. The representative figures and their theories include: Karl Popper's falsification theory of science, which claims a good scientific theory having falsifiability, and the development of science always being in the continuing falsification. Thomas Kuhn's theory of scientific revolution, which claims the development of science being