Chapter 1

Introduction

In the final decades of the nineteenth century, Newton's classical mechanics and his universal gravitation, Maxwell's classical electrodynamics and his aether ideas and the rapidly developing science of thermodynamics were absolute and seemed to have the answer to all questions about the physical world. However, at the same time, quietly behind the scenario, the number of unexplained experimental observations was rapidly growing up and demanding for new ideas and a new world-conception. The discoveries about the quantized radiation from atoms, molecules and metallic cavities have motivated the first steps toward the quantum theory. However, when Michelson announced the null results of his light anisotropy experiments, the scientific community was perplexed and a strong skepticism about the classical views opened the way for new ideas and new theories.

1.1. Modern Physics and the Great Scientific Revolution

The development of the quantum theory along the last hundred years has provided immense scientific prosperity, resulting in a wealth of experimental and theoretical discoveries. From these achievements the Principle of Uncertainty is the most emblematic characteristic of quantum mechanics. These discoveries have elucidated the physics, ruling the atomic, molecular and nuclear structures and now the quantum theory is about to give us full understanding about the physics of the elementary particles. The development of the quantum physics of the solids has generated new technologies with immense benefits for the human life.

On the other hand, in his revolutionary theory of relativity (TR) [1, 2], Einstein has abandoned Newton's ideas of the absolute space and absolute time and although seeing in Maxwell's equations support for his TR, Einstein has declined Maxwell's aether ideas for light. By his famous thought experiments he has unveiled many unsuspected and important physical effects, due to motion, which he attributed to relative velocity. According to the TR, relative velocity slows the rate of clocks, shrinks the lengths of bodies along the direction of the motion and increases the mass-energy of matter. According to the TR the result of measurements of time intervals, of lengths, of mass etc. depends on the relative velocity of the physical systems with respect to the observer's inertial reference. All these changes however are such that they do not affect the result of measurements of the velocity of light. According to the TR, the observed velocity of light is intrinsically constant and isotropic. The TR has lead to several important practical results, like for instance, the famous relation between mass and energy ($E = mc^2$), which has elucidated the origin of the nuclear energy and explained the source of the solar energy. The TR also has lead to radical changes, in the view about the nature of space and of the gravitational fields.

1.2. Main Achievements and Troubles of the Quantum Theory

According to quantum mechanics, the motion of particles must be conceived in terms of the propagation of wave-functions, the nature of which however has important differences from the classical mechanical waves. Mechanical waves are the propagation of local perturbations in the equilibrium state of mechanical media. They propagate along the normal to the wave fronts at a well-defined velocity, characteristic of each medium. If the medium is non-homogeneous, it refracts the waves and if the homogeneous medium moves, it drags the wave fronts with it at the same velocity. Water waves, for instance, propagate in the deep oceans at a characteristic velocity with respect to the local ocean water, without taking knowledge of the motion and rotation of earth or ocean streams. Ocean streams drag the waves at the exact velocity of the water in the stream. If the homogeneous medium moves non-uniformly, it drags the waves non-uniformly, thereby refracting the wave fronts according to a locally well-defined time rate, depending on the differential velocity of the medium. Refraction of sound waves, propagating through wind gradients or within whirl-wind, are well-known examples of such refraction effects [3]. Refraction of sonar in turbulent water is a serious problem for submarines.

However, electromagnetic waves and the de Broglie wave-functions of the elementary particles propagate in the vacuum. In the past century, many experiments tried to detect effects that could reveal the presence of a medium of propagation for light. However, systematically they all failed. This has lead to the conclusion that electromagnetic waves (light) and the matter waves need no medium of propagation. **Chapter 3** however will show why these experiments failed and that this failure, far from a disappointment, is the perfect signature of the true physical mechanism of gravity in action that Michelson and Einstein have missed.

According to Quantum mechanics, the motion of the elementary particles must be conceived in terms of complex wave-functions of the form $\Psi(r,t)=\psi(r)\mathrm{e}^{i(\boldsymbol{kr}-wt)}$, where $\psi(r)$ is an amplitude and $\mathrm{e}^{i(\boldsymbol{kr}-wt)}$ is a phase factor, in which $\boldsymbol{k}=\boldsymbol{p}/\hbar$ is the wave vector, $w=E/\hbar$ is the angular frequency (radians/sec) and w/k is the phase velocity of propagation along $+\boldsymbol{r}$. Normally the wave-functions are seen as pure mathematical constructs that have no tangible reality. Only the product $\Psi^*\Psi=\psi^2(r)$, in which the imaginary part is absent, is an observable. The most accepted interpretation of $\Psi^*\Psi$ is that it describes the probability density of observing the hypothetical particle within the small volume of a detector. This probabilistic interpretation looks like quantum mechanics in terms of classical concepts. In this probabilistic interpretation, the position and momentum of the associated hypothetical particle has an odd intrinsic arbitrariness that usually is explained in terms of the Principle of Uncertainty.

Many experimental observations show that the wave-functions (wave-packets) of particles and of light (photons) have fundamental differences. For instance, in the two-slit interference experiment with individual photons, the amplitude of the one-photon wavefunction has many maxima and minima on the screen. Observation nevertheless shows that each photon hits the screen at only one unique point. The way the photon chooses this point seems to be a true game of dice. However, after shooting many individual and monochromatic photons through the two-slit device, the hits on the screen distribute them according to a regular interference figure, consistent with the amplitude distribution of the interfering wave-functions coming from the two slits. This shows that this game of dice follows well-defined rules. Any attempt to find out through which slit the photon has passed, results in destruction of the interference figure. This observation demonstrates that the photon effectively behaves like a wave until hitting the screen, where this wave function collapses into a local effect and instantaneously deleting the wave-function throughout. This is a clear indication that the medium, propagating the photons, must be a quantum fluid, because only they can give rise to such an observation. In an analogous two-slit experiment with electrons the electron wave-functions follow entirely analogous interference rules as the photons. However, applying an electric or magnetic field on the two-slit reveals a radical difference. While the photon interference figure remains unaltered, that of the electrons changes completely. Even if the magnetic field $\boldsymbol{B}$ falls to zero on the slits ($curl\boldsymbol{A} = 0$), but a non-zero irrotational vector potential with different directions or differing intensities is present on the two slits, the interference fringes are displaced. The reason is the fact that the vector potential displaces the phase of the electron waves, as shown by the Aharonov-Bohm experiment [4]. These observations show that the nature of the wave-functions of the electrons is fundamentally different from those of the photons. The difference is electric charge. Electric charge allows the electron wave-functions to couple to electric, magnetic and even to irrotational vector potential fields, which displaces the phase of the electron waves.

Many experimental observations also have evidenced a number of other fundamental differences between the photon and the other elementary particle wave-functions. They can differ by a series of intrinsic attributes, like rest mass, spin, electric charge, hypercharges, isospin etc. Note however, that all these attributes are intrinsically quantized, which evidences their wave mechanic nature (not real in themselves, however propagating perturbation of some medium or field). These parameters or attributes divide the elementary particles into three families: quarks, leptons and force carriers (bosons). The elementary particles also may be classed in many other distinct groups: fermions and bosons, hadrons and leptons, baryons and mesons, leptons and neutrinos etc.

Quantization is an exclusive feature of wave mechanisms. Quantization of particle states (de Broglie waves), confined in a potential well is well understood in terms of the eigenstates and eigenfunctions (standing waves) of the