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History and Philosophy of Quantum Physics : An Overview

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The history of Quantum Mechanics (Physics) is more than a century old. The German Physicist Max planck presented the idea and concept of Quantum Mechanics in a meeting of the Berlin Academy of Science on December 14, 1900. The other superstars who contributed to the evolution of Quantum Physics are Albert Einstein, Niels Bohr, Satyendranath Bose, Louis de Broglie, Wolfgang Pauli, Erwin Schrodinger, Maurice Dirac, Enrico Ferini, Max Born and Werner Heisenberg. This short article will deal with the evolution of Quantum Physics and will also throw light on its philosophical aspects.

Introduction

The history of Quantum Mechanics (Physics) is more than a century old. Max Karl Ernst Ludwig Planck (1858-1947), Nobel Laureate in Physics, 1918, presented the idea and concept of Quantum Mechanics (Physics) in a meeting of the Berlin Academy of Science on December 14, 1900 (Latin Word: 'quantus' meaning how much-'quantum'-Singular, 'quanta'-plural). Quantum is a discrete unit quantity of energy proportional to the frequency of radiation. Quantum Mechanics attempts to describe the behavior of particles at the atomic level. Albert Einstein (1879-1955) first used Planck's theory of the blackbody radiation in his Nobel Prize winning work (1921) on photoelectricity (photon) establishing the recognition of the discrete and discontinuous nature of all matter, especially noticeable on the scale of the very small. Einstein used Planck's quantum theory to explain the photoelectric

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effect, the release of electrons by the atoms of a metal when bombarded with light.

It succeeded in explaining a physical phenomenon where Classical Physics of Isaac Newton (1642-1727) could not. The Danish physicist Niels Bohr (1885-1962), received Nobel Prize in Physics in 1922 for his theory of the quantum mechanical model of the atom. In 1927, Bohr introduced the concept of complementarity, stating that a classical description of an atomic phenomenon, such as momentum and position of an electron do not fit. The two complementary aspects could not be observed simultaneously—they are mutually exclusive, but both are valid and indispensable, and together they represent a more complete description of the small-scale phenomenon. This attempt to reconcile classical physics with the new quantum physics could be applied to light, for example, which could behave as a particle and as a wave but not both at the same time. This is known as Copenhagen Interpretation of Quantum Mechanics and it took into account the principles of complementarity and uncertainty.

The Indian physicist Satyendranath Bose (1894-1974) in the path-breaking research on quantum statistics in 1924 known as Bose—Einstein Statistics ("Planck's Law and the Hypothesis of Light Quanta") explained Max Planck's black body radiation without the use of classical electro-dynamics. Bose is also the Father of Boson now known as Higgs-Boson ('God's particle).

The same year, the French physicist Louis de Broglie (1892-1987, Nobel Laureate in Physics in 1929), suggested that all matter display characteristics of both waves and particles but that wave characteristics were only observable at the atomic level. This concept developed into the field of wave mechanics, which grew into quantam mechanics.

In 1925, the Austrian physicist Wolfgang Pauli (1900-1958, Nobel Laureate in Physics, 1945), announced that in any system of elementary particles, no two particles move in the same way. In other words, no two electrons could occupy the same energy state simultaneously. This is known as 'Pauli Exclusion Principle' and explained why all electrons of an atom did not occupy the lowest energy level.

The Austrian physicist Erwin Schrodinger (1887-1961) formulated a useful equation in 1926 that described how electrons behave in an atom and is now considered the origin of quantum mechanics. The English physicist Paul Adrien Maurice Dirac (1902-1984) extended Schrodinger's work to more fully describe an electron's properties, allowing the prediction of an electron's spin and magnetic change. Dirac and Schrodinger shared the Nobel Prize in Physics in 1933. Dirac wrote the first physics text explaining quantum mechanics— "The Principles of Quantum Machanics" (1930)—considered still a classic in the field. The Italian physicist, Enrico Fermi (1901-1954, Nobel Laureate in Physics, 1938), formulated the quantum statistics of Fermian particle.

In 1926, the German Physicist Max Born (1882-1970), co-winner of Nobel Prize in Physics in 1954 with another German Physicist Walther Wilhelm Georg Franz Bothe (1891-1957), said that the rise and fall of waves represented the fluctuating probability that an electron behaved like a particle. Both Born and Bothe postulated the statistical formulation for the behavior of subatomic particles.

The Uncertainty Principle "proposed by the German physicist and philosopher Werner Karl Heisenberg (1901-1976, Nobel Laureate in Physics, 1932), stated that the position and velocity of an electron cannot be determined accurately at the same time. One only could predict statistically where an electron will go when it is hit. He said: "Nature abhors accuracy and precision above all things.

All these physicists were Quantum Super Stars.

Analysing the evolutionary history of the post 100 years of Quantum Mechanics, we can conveniently set the following three main phases :

i. End of the 19th century — 1912 : Basis of Quantum Mechanics was built through analysis of its experimental aspects.

ii. 1913-1922 : Neils Bohr's Quantum theory was based on the study of hydrogen atom.

iii. 1923-1932 : Consolidation and establishment of Quantum Physics.

During the end of the 19th century and the beginning of the 20th, the spectre of the 'Quanta' spread its influence on different branches of physics — atomic spectroscopy, blackbody radiation, photoelectric effect, solid state physics, atomic structure etc. and laid the foundation of a co-ordinated approach among different branches of physics.

Quantum Mechanics was the basis of the pioneering work on quantum electro dynamics (QED) by American physicist Richard Feynman (1918-1988), Co-Nobel Laureate in Physics in 1965 with the Japanese physicist Shinichiro Tomonaga (1906-1979) and another American physicist Julian Schwinger (1918-1994). Their fundamental work in QED had profound consequences for elementary particle physics. The "Eightfold Way" Scheme of the American physicist — Murray Gell-Mann (1929-) proposed *quarks* as the ultimate building blocks of matter and this led to the development of quantum Chromodynamics as the field theory explaining the force responsible for holding atomic nuclei together. Gell-Mann was awarded the Nobel Prize in Physics in 1969 for his contribution and discoveries concerning the classification of elementary particles and their interactions.

There are still many queries and questions about Quantum Physics. Its very founders — Planck and Einstein became skeptical about it in their later life. There was a great debate between Einstein and Bohr on the relationship between quantum and the nature of reality. But the story goes on even today and science surges on to explore the unknown mystery of the creation of the universe. Einstein said: "Though Quantum Mechanics is free from logical inconsistencies, it can at best be an incomplete description of physical reality".

The microuniverse does not seem to obey the rules of 'creative destruction' (that is, elimination of the old and installation of the new). Tiny to tinyest particles co-exist in a dynamic fashion–always in cooperation and conciliation and never in confrontation. There is unity in diversity.

On the contrary, maco universe religiously obey the rules of creative destruction. "Chandrasekhar Limit" is the example.

"Chandrasekhar Limit" (1.14 times a solar mass) postulated by the Indian physicist Subrahmanyan Chandrasekhar (1910-1995) in 1930 (when he was a student in Cambridge University, U.K. plays a crucial role in understanding the stellar evolution. If the mass of a star exceeded this limit, the star would not become a white dwarf. It would continue to collapse under the extreme pressure of gravitational forces. The formulation of "Chandrasekhar Limit" led to the discovery of white dwarf, neutron star and black hole depending on the mass of the star. The white dwarf is a star of low mass in its final phase of stellar evolution, resulting from its gravitational collapse after it's thermonuclear fuel has been exhausted. The neutron star is a small, superdense star composed mostly of neutrons. They are thought to form when massive stars explode as super novae, during which the protons and electrons of the star's atoms merge, owing to intense gravitational collapse, to make neutrons. A neutron star may have the mass of upto three suns, compressed into a globe only 20 lm/12 mile in diameter. It its mass is any greater, its gravity will be so strong that it will shrink even further to become a black hole. The black hole is a hypothetical object created when a sufficiently massive star undergoes gravitational collapse within a certain radius. The gravitational field of the black hole is so strong that even light waves can not leave the body, with the result that a black hole can never be observed.

For his epoch—making work on stellar evolution in 1930's, Chandrasekhar was awarded the Nobel Prize in Physics in 1983, jointly with the American nuclear astrophysicist William Alfred Fowler (1911-1995). It took more than 40 years for Chandrasekhar to have his brilliant discovery universally recognized.

Better late than never.

The Philosophy

In exploring the ultimate reality of Nature, physics today has entered the domain of metaphysics of the Greek philosopher Aristotle (384-322 BC) and even beyond. The hard materialism of the classical physics of the French mathematician, scientist and philosopher Rene Descartes (1596-1650), French mathematician, astronomer and physicist Pierre-Simon de Marquis Laplace (1749-1827) an the English scientist and mathematician Isaac Newton (1642-1727) started softening with the concept of macro-universe of relativity and mass energy dualism of Albert Einstein, the sub-atomic wave-particle equation of Erwin Schrodinger, the probability wave-concept of Max Born and the Uncertainty Principle of Werner Heisenberg. So it seems that modern physics is coming very close to the concept of Vedantic Monism—at least at the conceptual phases.

The parallel quest of physics and philosophy is identical regarding creation—its beginning, working, and the end, if any. Modern physics has turned from the properties of Nature to the essence of it—the ultimate reality.

The certainty of science is a significant path to the divine destination through methodical explorations into the layers of matter leading to consciousness. The English theoretical physicist and cosmologist Stephen William Hawking (1942-), former Lucasian Professor of Mathematics, University of Cambridge, England (chair once held by Newton) dreamt of unity in diversity and a single cosmic principle to explain all physical interactions by one set of equations uniting Newton's gravitation, Einstein's relativity, James Clerck Maxwell's (1831-1879) electromagnetism and the quantum dynamics of subatomic events.

The Copenhagen Interpretation of quantum mechanics generated the idea that the universe is a creation of mind-stuff. The probability wave of Max Born speculated that photons and electrons might be conscious or organic. Even the English mathematician and philosopher, Roger Penrose (1931-) also postulated that human consciousness is based on the basic principles of Quantum Physics. Thus mind-matter dualism is no longer a mystical thinking of only the East; it is the basic presumption of modern physics as well.

In the light of quantum theory, elementary particles are not real like other objects of daily life and verges on the borderline of existence and non-existence. The American physicist John Archibald Wheeler (1911-2008) speaks of a "quantum foam" in which every particle is connected with every other particle with a quantum inter connectedness, all of which are also subjected to super-space.

Heisenberg's Uncertainty Principle held that Newton's law of cause and effect is not applicable in the quantum world and human consciousness is a hidden variable or participator in the objective reality of quantum drama. Hence flowed the idea of an omnijective reality — subjective + objective — and if we have one constant sphere, that will be psychic. This is what is called a self-created universe—that is a projection of the cosmic mind and the world of cause and effect is, cosmic delusion or 'Vedāntic Māyā'.

Max Planck's idea of consciousness in material reality, the concept of omniobjective universe, Wheeler's concept of self-organising systems — all removed the age-old division between mind and matter, pointing to the possibility of Consciousness as creator of the Universe.

Microphysical indeterminacy of Heisenberg raised the vital question whether physics should only deal with subjects of experiments or take intuitive leaps as well. Einstein commended cautiously on this point:

> "Not everything that can be counted always counts, and not everything that counts can be counted."

Here lies the dilemma of all scientific experiments. It is partly solved by thought experiments.

Penetrating physical reality reveals the psychic sphere and a field of massive integrated consciousness, Erwin Schrodinger rightly said :

> "In all the world there is no kind of framework within which we find consciousness in the plural. This is simply something we construction….

The only solution to this conflict, in so far as any is available to us at all, lies in the ancient wisdom of the UPNISHAD."

The Epilogue

The creation of the universe is still a riddle wrapped in mystery inside an ensgma. Max planck apprehensively commented on the limitations of science :

> "Science cannot solve the ultimate mystery of nature. And that is because, in the last analysis, we ourselves are part of nature and therefore part of the mystery we are trying to solve."

However, the desire to explore any mystery is a human instinct and in the world of science it is a constant incentive to discover new things. But the quest continues and we remain optimistic.

"To see a World in a Grain of sand,
And a Heaven in a Wild Flower,
Hold Infinity in the palm of your hand,
And eternity in one hour."

[William Blake (1757-1827): "Auguries of Innocence"—First stanza]

Suggested Reading

Manjit Kumar (2008) : "Quantum : Einstein, Bohr and the Great Debate about the Nature of Reality", Icon Books, United Kingdom.