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Impact of Relativity Theory and Quantum Mechanics on Philosophy

Devinder Pal Singh

Department of Physics,
Shivalik College, Naya Nangal 140 126

Abstract—In present times, Science has undergone a drastic change due to the critical examination of its methods of acquiring scientific knowledge. It has become more and more contiguous to philosophy. Relativity theory and Quantum Mechanics have revolutionized our concept of classical physics in its analysis of matter and has created not only a new mathematical symbolism but a revision of a large number of its basic concepts. Relativity has shown that all material objects and processes exist in integral form of space-time, of which the relations of space and time are different but inseparable aspects. Its modifications of our classical concepts of mass, length, force, law of addition of velocities, principle of simultaneity alongwith a new interpretation of laws of conservation of energy, mementum and angular momentum are of more universal nature. The theory of relativity has demonstrated for the first time the inner necessity of the idea of dialectical contradiction in theoretical development of the concepts of physics.

Quantum mechanics has continued, which began in physics with the advent of theory of relativity. With the development of quantum mechanics the notion of a strict continuity in the spectrum of values of physical quantities is no longer valid, the classical concept of trajectory is rejected, the principle of classical determinism is questioned. The classical principle of unlimited detailing of objects in space and of phenomena in time is rejected. The concept of energy, momentum and angular momentum are now seen differently with a reconsideration of the previous inter-connections, taking into account the possibility of quantization and the limitations imposed by the uncertainty relations. It has shown that the basic laws of nature are not dynamic but are statistical and that the probabilistic form of causality is the fundamental form while the classical determinism is just its limiting case. Quantum mechanics lays emphasis on relations of a qualitatively different dialectic type, like the relations of complementarity and relations of interference.

state. With the advent of general theory of relativity, the distinction between inertia and gravitation has disappeared. The gravitational action between two bodies follows from the same equations, and is the same thing, as the inertia of one body. A body under gravitational effect describes a geodesic in 4-D continuum, just as it describes a straight line, in the absolute space of Newton under the influence of inertia alone.

The geometry of spacetime[3] is not the same as that of piece of paper and the shortest distance between two events is generally not a straight line. We are familiar that the shortest distance between two points is a straight line. This is true in ordinary space but not in specetime.

Although Newton's laws of motion have been altered by relativity theory[3], the direct connection between the symmetry of space and the conservation of momentum has been unaffected or even strengthened by this modern theory. All the three conservation laws of energy, momentum and angular momentum are understood in terms of the symmetry of spacetime and indeed the relativity theory has shown that these three laws are all part of a single general law in the four-dimensional world.

Absolute Concepts in Relativity Theory

The relativity theory has given birth to several absolute concepts.[5,6] It has abolished the framework of absolute space and absolute time and replaced them by absolute spacetime. Among the paraphernalia of relativity theory, the speed of light is absolute, the pattern of curved space near a massive object is absolute, the rest energy of an object is absolute, and all the laws of physics are absolute, not in the sense of being unalterable by the progress of research but in the sense—they are consistent throughout the universe.

Quantum mechanics has continued which began in physics with the advent of theory of relativity. A transition from macrophenomena to micro-phenomena presupposes a rejection of the basic ideas of classical physics [7,8].

Wave—Particle Duality

In the world of macro-phenomena, the corpuscular and wave motions are clearly distinguished. These usual concepts, however, cannot be transferred to quantum mechanics. In the world of microparticles the above-mentioned strict demarcation between the two types of motion is considerably obliterated. The motion of a microparticle is characterized simultaneously by wave and corpuscular properties. This is known as wave-particle duality, which is unknown to earlier physical conceptions of physics and philosophy. The advent of quantum mechanics has shown that all material particles have wave properties, which can be exhibited under suitable conditions. The rejection of the trajectory concept in quantum mechanics is connected with the existence of wave properties in microparticles, which do not permit one to consider microparticles as classical corpuscles.

Determinism and Uncertainty Principle

Determinism[9], the philosophical doctrine that the universe is a vast machine operating on a strictly causal basis, with its future determined in detail by its present state is rooted in the Newtonian model of mechanics. The uncertainty principle due to Heisenberg establishes the impossibility of simultaneous determination of the position and momentum of an atomic particle with an arbitrary accuracy. The uncertainty principle in quantum mechanics has established the limit of applicability of the classical concepts of a particle, by bringing our attention to the fact that, let us say, electrons and protons possess wave properties as well as corpuscular properties. It is a consequence of the advent of this principle that physics is no longer pledged to a scheme of deterministic law.[10] The mechanical determinism of classical mechanics has been relegated to be an article of faith and has been elevated to the status of philosophical principle for the science of macroscopic phenomena.

Conservation Laws

In quantum mechanics, it is the uncertainty relation which shows how the concepts of energy, momentum and angular momentum should be applied in the case of microparticles. Here a very important peculiarity of the physics of microparticles is revealed ; the energy, momentum and the angular momentum of a microparticle have meaning only within the limitations imposed by the uncertainty relation.

Problem of Measurement

In quantum mechanics, it is impossible to neglect the interaction of the microparticle with its surroundings. In order to be "seen" by an observer the microparticle causes a complete "catastrophe", an 'explosion' on the scale of microphenomena. The "observable" microparticle might perish in the "catastrophe" caused by it. Thus in the quantum mechanics the investigator and the object of investigation can not be completely isolated from each other.

Chance and Necessity

While Laplacian déterminism[10] excludes the element of chance from the behaviour of an isolated object in classical mechanics, necessity completely dominates. But in quantum mechanics elements of necessity as well as chance are present. An excited atom spontaneously returns to the ground state without any external influence. Such a return is random act. So element of chance is present in such transitions. Necessity in quantum mechanics is manifested in the conservation laws which govern decay processes as well as the processes of interconversion of microparticles in general. To describe reality, the concept of necessity and chance are important aspects of a physical theory. The importance of these elements is emphasized by quantum mechanics.

Possibility and Actuality

With the establishment of quantum mechanics the importance of the problem of the possible and actual has increased manifold. As we know, every particular situation (e.g. decay of an elementary particle) is characterized by a set of possibilities out of which only one is realized. The realization process is irreversible; as soon as it is accomplished, the initial situation qualitatively changes. The possibility that had been realized corresponds to a new situation with new possibilities. The process of resolving the contradictions between the possible and the actual thus turns out to be endless. It is the measuring process which resolves the dialectical contradiction between the possible and the actual in quantum mechanics. In the interaction process of a microparticle with the detector (during measurement process) the resolution of distinction between the possible and the actual takes place, the superposition of probabilities is destroyed and is replaced by one of the alternatives realised.

Concept of Causality

According to the empiricists, the idea of causality involves nothing more than the idea and expectation that one event will always be followed by another. It does not tell about any link between the cause and the effect. But in quantum machanics the principle of causality refers to the possibilities of the realisation of events. In quantum machanics, it is not individually realized events that are causally related, but only the possibilities of the realization of these events. The quantum mechanical principle of causality is a generalization of the principle of classical determinism.

Principle of Complementarity

The dialectical nature of quantum mechanics is reflcted in the principle of complementarity put forth by Bohr. It states that in any experiment with microparticles the observer gets information not about the "properties of the particles themselves" but about the properties of the particles associated with some particular situation including among other things, the measuring instruments. The information about the object obtained under some definite conditions should be considered as complementary to the information obtained under different conditions. Essentially the information obtained under different circumstances cannot be added, accumulated or combined into a single picture; it reflects various sides (complementing one another) of a single reality, to wit the object under investigation. The principle of complimentarity finds a direct expression, in particular, in the idea of wave-particle duality and in the uncretainty relation.

Physical Reality

With dawn of 20th century, physical reality was conceived to be represented by continuous field, not mechanically explicable, which is subject to partial differential equation. The special and general theories of relativity, which though based entirely on idea connected with the *field theory*, have so far been entirely unable to avoid the independent introduction of material points and total differential equations. Quantum mechanics differs fundamentally from the above given scheme. For the quantities which figure in its laws make no claim to describe physical reality itself, but only the probabilities of the occurrence of a physical reality that we have in view.

Dialectics in Relativity Theory and Quantum Mechanics

It is true that dialectical nature is inherent in every physical science to some extent. But relativity theory and quantum mechanics have convincingly shown that a higher level of knowledge of the laws of nature is inevitably linked with a deeper and more serious knowledge and application of the methods of materialistic dialectics. The rise of the theory of relativity itself cannot be understood without and independently of the idea of dialectical contradiction.[1] Einstein combined the two mutually contradictory principles in a truly dialectical manner and constructed a new fundamental physical theory, in which the principle of relativity and that of constancy of the velocity of light figure as necessarily related to each other.

In classical physics space and time existed separately, in mutual isolation. In the relativity theory space and time are regarded as forming an integral system each component of which is objectively impossible and unimaginable without the other. The equivalence relation between mass and energy, inertia and gravitation and unification of field and particle concepts in this theory confirms its dialectical nature.

Recognition of the unity of the opposing corpuscular and wave conceptions of matter is a necessary element of quantum mechanics. Quantum mechanics lays emphasis on relation of a qualitatively different, dialectical types, like the relations of complementarity and relations of interference. In quantum mechanics the dialectical categories of necessity and chance, possibility and actuality are applied not only to the ensembles of objects but also to an individual microparticle. Thus, quantum mechanics has clearly demonstrated the dialectical struggle between form and content. It has shown that no content can be grasped without a formal frame and that any form, however useful it has hitherto proved, may be found to be too narrow to comprehend new experience.

Appearance and Reality

The doctrine of materialism[6] asserted that space, time and material world comprised the whole of reality. The relativity theory and quantum mechanics have shown very clearly that all earlier systems of physics, from the Newtonian mechanics down to the old quantum theory, fell into the error of identifying appearance with reality; they confined their attention to that the world of reality consisted of only distinct parts, that the sharp boundaries existed between events and objects. Relativity theory and quantum mechanics have clearly shown that we must probe the deeper substratum of reality before we can understand the world of appearance, even to the extent of predicting the results of an experiment.

Concept of Unobservables

The classical theories of physics deal directly with quantities which are measurable, usually called observables. Force, mass, velocity and almost all the other concepts described by the classical laws are themselves observables.[3] The relativity theory contains certain quantities which are not themselves observable. Space itself may be regarded as an unobservable. Packets of curved space—tidal ripples—gravity waves and gravitons are other unobservable concepts. The equations of quantum mechanics also contain certain quantities which are not themselves observables. From these quantities (unobservables)--the observables are derived. The wave function is one of the unobservable quantities. Thus it has become increasingly evident in recent times that nature works on a different plan. Her fundamental laws do not govern the world as it appears in our mental picture in any direct way, but instead they control a substratum of which we cannot form a mental picture without introducing irrelevancies.[7]

Unity of Universe

Relativity theory[3] and quantum mechanics[8] re-establish the idea acquired through every day experience regarding the unity of the universe and general connection among phenomena. The sharp boundaries that existed between space and time, mass and energy, inertia and gravitation, fields and particles, waves and particles, object under investigation and the medium are all obliterated and the concept of the inter-conversion of matter is introduced. We are led to picture the world as an indivisible, but flexible and ever-changing unit.

Conclusions

The relativity theory and quantum mechanics emerged and developed as a result and expression of the human knowledge's penetration into the sphere of the most refined electromagnetic phenomena, into the atomic and subatomic world and into the field of immense cosmic phenomena while converting the objects comprehended by the 19th century physics, from new angle.

Recognition of the unity of the different and isolated concepts is a necessary element of these theories. Acceptance of the idea of an internally necessary connection between several isolated concepts, is a characteristic of the philosophy of our day. As a consequence of the advent of these theories, a large scale revision of physical concepts, especially of physics and philosophy in general, has taken place.

These theories have called for the rejection of the many usual and accepted notions such as absolute simultaneity, existence of forces acting at a distance, mass as a constant quantity, separate identity of mass and energy, the strict continuity of the spectra of values of physical quantities, the trajectory as an essential attribute of the motion of an object, Laplace determinism as the basic form of expression of the principle of causality, the possibility of an infinite detalization of the structure of an object in space or of a phenomenon with respect to time, the possibility of distinguishing between two objects, however, similar to each other, under any circumstances at least in principle, to disregard the measuring instrument when conducting any measurement.

The relative character of measurement of space, time, distance and concepts of "straight" and "curved", appearance and reality is established. New absolutes of universe such as constancy of velocity of light, universal applicability of physical laws, etc. have been invented. Inertia, gravitation and metrical behaviour of bodies and clocks are reduced to a single field quality. These theories have demonstrated concretely that the concepts of classical mechanics and science as a whole for instance, are of course, essentially approximate. Thus, though these theories are purely physical theories, yet these have a very wholesome influence on metaphysical theories.

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