IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 4, Issue 11, November 2017

The 'Cause' and 'Effect' Formalism in Physics

Dr.(Prof.) V.C.A. NAIR*

Educational Physicist, Research Guide for Physics at JJT University, Rajasthan, India
*nairvca39@gmail.com

Abstract: A rare exposition on the title with excerpts from famous books such as 'Physics and Philosophy', 'The Nature of the Physical World', 'Quantum Theory', 'The Tau of Physics', The Fire in the Equations', and 'Euclid to Eddington' written respectively by Heisenberg, Eddington, David Bohm, Fritjof Capra, Kitty Ferguson, Edmund Whittaker, to mention few. The entire Paper is given a philosophical touch starting from Classical Physics to Quantum Theory. The reader will (I hope) appreciate the philosophical views given by each of them. As a picture speaks thousand words, and as 'Face is the Index of the Mind', I have added the pictures of the scientists at appropriate places. In addition to the references, author has added some of his personal views on the topic.

Keywords: Cause and Effect, Causation, Causality, Canons of Induction, Doctrine of Determinism, Events in four-dimensional space-time, Law of Causation, Necessity and Chance.

I INTRODUCTION

1.1 General:

Akin to 'Gravity', the entire universe is governed by the concept of 'Cause' and 'Effect' the origin of which is from time immemorial. It started at the very early stages of the universe even at the time of its creation. The very formation and existence of the universe is with some cause and the same is still under investigation. The primitive man has felt the heat of the Sun, observed the formation of clouds in the sky and also experienced the devastation created by volcanoes, earthquakes and the tsunamis. But, he did not bother about the 'How' and 'Why' of these events till some thoughtful men (whom we regard today as 'scientists') came forward and reasoned of such events and because of such reasoning, we are today in a position to answer questions regarding such events. The questions of How? and Why? are much related to 'Cause' and 'Effect' The cause for rain is the evaporation of sea water and formation of clouds. The effect is the condensation of clouds and arrival of rain. Similarly, the cause for the formation of rainbow in the sky is both the sunlight and the rain drops. One or more agency can be the cause creating one or more effects.

1.2 The Cause and Effect Formalism in scientific research:

Experimentation forms a major part of scientific research as the same is essential for the verification and hence the confirmation of any theory. The cause and effect formalism is inherent in any experimental process. Whether it is a simple experiment such as the flow of current from a battery through a resistor or the proton-proton interaction in the Large Hadron Collider (LHC) at Geneva, the cause and effect formalism is inherent in both the processes. Taking the first and the simplest one of flow of current from a battery shown Fig.1. The formalism of cause and effect is no concern for the

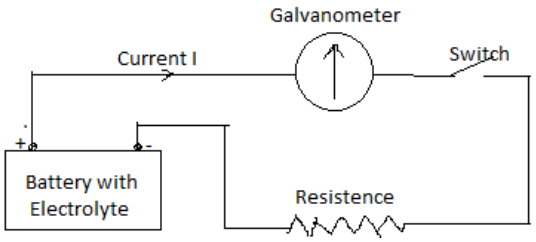

Fig.1 Galvanometer showing current from a battery

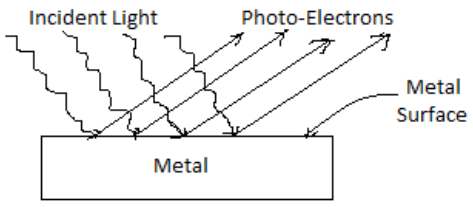

Fig.2 The Photo electric Effect

experimenter. But, the philosophy involved is vast and universal. The chain of events taking place in the circuit are:

The Battery with the electrolyte creating an Electromotive Force (EMF) → Putting the Switch on → → creating a Potential Difference (PD) → Flow of Current → Force on current-carrying conductor in the magnetic field of the coil of Galvanometer → Motion of Pointer of Galvanometer.

The quantity on the left of the arrow becomes the Cause and the quantity on the right of the arrow becomes the Effect. Thus, the Cause and Effect form a cascade whether it is science or in any walk of life.

Another simple example is the Photo electric effect shown Fig.2. Light from a source is incident on a metal surface is the Cause for knocking out electrons from the metal surface which is the Effect. Going for very complicated experiments such as the ones taking place in the LHC, which is the biggest Physics Machine in the world is filled with the jugglery of thousands of Cause and Effects in the world.

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 4, Issue 11, November 2017

REVIEW OF LITERATURE

II THE PHILOSIOPHY OF CAUSE AND EFFECT

2.1 The origin and ancient views:

M.E Omelyanovsky [9] mentions that in ancient philosophy the concept of cause was more general and undefined than it is today, and Aristotle, that great encyclopedic mind of antiquity, distinguished four kinds of causality; *Causa formalis, Causa materialis, Causa efficiens and Causa finalis.* These terms can be found in modern philosophical literature, but the meanings given to them by Aristotle are now referred to other more accurately defined categories. Only the term causa efficiens (the efficient cause) has to some extent retained its meaning which corresponds approximately to the modern meaning of the word 'causality'

Lenina Ilitskaya [1] the Russian translator of ABC'S Dialectical and Historical Materialism has randomly dealt with lot of ideas regarding cause and effect which I would like to briefly enumerate here:

It was believed that the ability of bodies to burm was due to a special substance, "*Phlogiston".* The more phlogiston in the body, the more readily it burned, and a body which had given off all the phlogiston could not burn. This phl;ogiston was always the cause of fire and fire was thus the effect of phlogiston. Another contemporary view was that heat was caused by a weightless substance called "*Caloric".* According to that view, a cold body became hot owing to the flow of caloric into it from a hot body. Thus, caloric is the cause and heat is the effect.

In contemporary Physics, cause and effect started with the "falling of the apple". Sir Isaac Newton, (1642-1727) (Fig.3) the English mathematician, astronomer, theologian and physicist born on Christmas day in 1642 was just 23 year old when he noticed an apple falling down in his Lincolnshire farm (Fig.4). We may say that the the starting point of Modern Physics started with 'Gravity' a very important concept

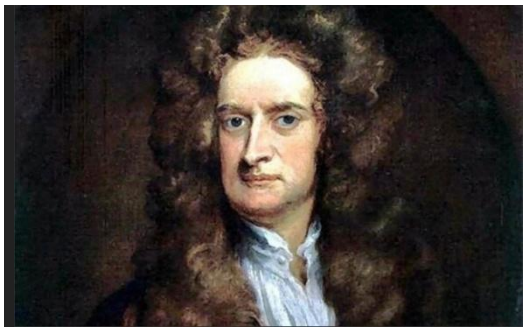

Fig. 3 Sir Isaac Newton (1642-1727)

Fig. 4 Newton watching the fallen apple

on which is built the present astronomy and astrophysics. The effect of falling of the apple, Newton sought for its cause and hence the universal law of gravity was born. In fact, the cause and effect is inherent in his laws of motion. 'Force' is the basic cause for both the vectors 'momentum' and 'acceleration'

In the laboratory experiment of Fig.1 for noting the current in a circuit, the abrupt and instant movement of the pointer of the galvanometer on passing the current is worth noting. Now-a-days, people who are paid well, do not follow and obey instructions and carry on their work sluggishly and reluctantly. The abrupt motion of the pointer without any hesitation, I would call it a sort of *"Scientific Obedience"* and strictly followed by all physical systems in the universe. In the biological sciences, anything that moves is said to have life in it. The lively motion of the pointer makes us believe that a sort of life of quasi nature gets associated with the working of the instrument. The same is the case with the motion of electrons around the nucleus of an atom. One can site many examples. From this point of view, I make a statement here: *"Physics is more lively than any living Biological Science".* Coming to cause and effect, in the illustration of current flowing in the galvanometer, basically current is the cause and movement of the pointer is the effect. As a counter question, *if somebody asks, what is the cause for current? As already pointed out earlier, it is the EMF, P.D, etc. What is 'Electricity?' itself is a counter question here.

---

*There are and can be many counter questions in Physics. In the past ancients asked many counter questions and that is how the subject was developed. While teaching 'Electricity' to Diploma in Engineering students, I asked a question, *"What is Electricity?"* and I myself answered by asking a counter question, *"What is NOT Electricity?"* meaning thereby that everything is electricity. My answer is from the point of view of structure of matter with the charged electrons moving around the nucleus of atom constituting a current

---

If we regard the links in the chain of causality as processes, we shall find when processes X in acting on processes Y, causes a change in it; processes Y in acting on processes X in turn, also causes change in it, so that the change looks like this:

$$X \rightleftarrows Y$$

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 4, Issue 11, November 2017

Consequently, every process as it acts on another process, itself is acted upon by the latter which means that all relationships which exist in nature and society interact and that the opposite (cause and effect) are comprised in one and the same thing or event.

2-2 The Doctrine of Determinism:

In the philosophical language we use the word 'causality' for 'cause' as both are nouns and in the philosophical literature the concept of causality is used to have more than one meaning. Before we enter into the deep ideals of this philosophy, we must ponder over a quantity what is known as *"Determinism"* Determinism is a doctrine that human action is not free but determined by motives regarded as external forces acting on the will. Both causality and determinism are correlated. That is, the former is identified with the necessary relations of the basis of a system where the initial state of a system necessarily determines its state at any subsequent time. This meaning of causality is usually termed 'classical determinism'.

Classical determinism is a particular case of relationship of states when the relationship is of a particular nature and is possible only when the system does not experience any external actions. i.e. in the case of isolated closed systems. As there are no absolutely isolated systems in nature, the concept of classical determinism is seldom followed. Causality is also employed in a meaning that might be defined as mathematical determinism. Mathematical determinism is involved when a differential equation (ordinary, partial or non-linear) in some mathematical form of expressing the behavior of a physical system and for definite initial and boundary conditions has a unique solution. The Soviet quantum physicist, Vladimir A. Fock (1898-1974) has pointed out that causality in the meaning of mathematical determinism is used in theoretical Physics.

In the treatment of causality, there exists another determinism due to the French scholar, Pierre Simon Marquis de Laplace (1749-1827) (Fig.5) known as 'Laplace Determinism' This determinism appears to permit full elucidation of all causes of any phenomenon and to identify (at least in principle) causality with unambiguous predictability, actually proved to be greatly exaggerated due to the restricted applicability of classical mechanics. Laplace determinism expresses the ideal of absolute knowledge, when an absolutely perfect knowledge of the initial state of a classical determinate system and a knowledge of the law of variation of the states permits of an absolutely exact prediction relative to the future of the system. We can see how the concept of determinism is applied in various branches of Physics. In Classical Mechanics and Electrodynamics of Maxwell, Laplace determinism coincides with mathematical determinism because Newton's equations and Maxwell's equations allow for unambiguous predictions of a future state of a system if one knows the state of the system at a given time and the forces or sources of currents and electric charges.

In the Quantum Field Theory, microprocessors are reflected not by a function but by a field operator that satisfies definite field equations which form a system of infinite number of differential equations which are not easy to be solved. The field operator functions that satisfy the equation of Quantum Field Theory, like the Schrodinger wave equation, expresses a probability of certain processes under given conditions. For this reason, even if the field equations satisfied by field operators had a unique solution for the given initial conditions it is difficult on the basis of this solution predict unambiguously the behavior of a quantum field if the mathematical determinism is present in the quantum field theory in general, it does not coincide with the Laplace determinism.

Fig.5 Pierre-Simon, Marquis de Laplace (1749-1827)

Fig.6 Sir Arthur Stanley Eddington (1882-1944)

Fig.7 Werner Karl Heisenberg (1901-1975)

III THE VIEWS OF SOME EMINENT PHILOSOPHER-PHYSICISTS

3.1 Preamble: Some preliminary knowledge is required for the section that immediately follows.

B. Yavorsky and A. Detlaf [14] correlated the theory of relativity with causality. The authors considered two events in a four-dimensional space which is an imaginary concept of space having 4 dimensions. The 3 co-ordinates x,

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 4, Issue 11, November 2017

y, z and time t are plotted. Any event in this space is represented by a world-point. The motion of a particle is represented by a line called world-line. The interval between two events can be written as

$$S_{12} = \sqrt{[c^2 (t_2 - t_1)^2 - (x_2 - x_1)^2 - (y_2 - y_1)^2 - (z_2 - z_1)^2]}$$

The interval between two infinitesimally close intervals is

$$dS = \sqrt{[c^2 dt^2 - dx^2 - dy^2 - dz^2]} = \sqrt{[c^2 dt^2 - dl^2]}$$

where $dl^2 = (dx^2 + dy^2 + dz^2)$.

Dealing specifically, if x_1, y_1, z_1, t_1 and x_2, y_2, z_2, t_2 are the world points of two events in a certain frame of reference K', then under the condition that $S_{12}^2 > 0$ (realness of the interval), there exists a frame of reference K in which both events take place at a single point in space ($x_1' = x_2'$, $y_1' = y_2'$ and $z_1' = z_2'$).

Real intervals are said to be time-like. The time $t_{12}' = t_2' - t_1'$ that elapses between the two events in frame K' is equal to $t_{12}' = \frac{S_{12}}{c}$.

The condition,

$$S_{12}^2 = c^2 t_{12}^2 - l_{12}^2 = \text{Constant and} > 0$$

where $t_{12} = t_2 - t_1$ and

$$l_{12}^2 = [(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2]$$

can be represented graphically as a hyperbola (Fig.8)

If $l = l_{12}$ and $c\,t = c_{12}$ are plotted along the co-ordinate axes where l_{12} and t_{12} correspond to the two given events in an arbitrary frame of reference, points A and A_1 correspond to event 2 which occurs at the same point in space as event 1 (Point O) but either later (Point A) or earlier (Point A_1). For example, in a causality relationship, if event 2 is the effect of event 1 (Point A), it must occur later. If two events that occur in a certain frame at a single point of space are causally related, then in any other inertial frame of reference, they are related in exactly the same way (for instance the switching of a galvanometer and movement of its pointer as in Fig.1) . Causality related events may also occur at different points in space, but in such a way that the effect is related to its cause by some process of propagation (for instance, turning on the light switch and the ignition of the electric lamp). The causality related events correspond to one branch of the hyperbola. The region above the asymptotes of the hyperbola is called the 'Absolute future' in relation to the initial event O. The sequence of cause and effect is determined by the direction of time. It is objective in nature and the theory of relativity consequently does not contradict the objective nature of causality.

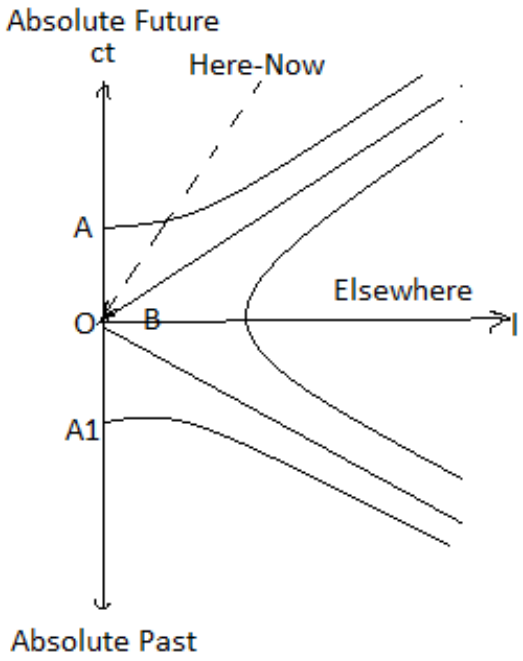

Fig.8 The 4-dimensional space-time continuum

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 4, Issue 11, November 2017

3.1.1 The views of Sir Arthur Stanley Eddington (1882-1944) [5]

The English astronomer, physicist and mathematician, Sir Arthur Stanley Eddington (Fig.6) in his famous classical book, "The Nature of the Physical World" states that – "The fact that a causal basis had been lost sight of the new theories was fairly well known; many regretted it and held that its restoration was imperative and adds a further foot note: "A few days after the course of lectures was completed, Einstein wrote in his message on the Newton centenary". "It is only in the quantum theory that Newton's differential method becomes inadequate and indeed strict causality fails us.. But the last word has not yet been said. May the spirit of Newton's method give us the power to restore unison between physical reality and the profoundest characteristic of Newton's teaching – strict causality". *(Nature, 26th March 1927, p.467)*

Eddington further continues in his book with a sub-title, "Causation and Time's Arrow":

Cause and effect are closely bound up with time's arrow; the cause must precede the effect. The relativity of time has not obliterated this order. An event Here-Now (Faig.8) can only cause events in the cone of Absolute Future'; it can be caused by events in the Cone of Absolute Past; it can neither cause nor be caused by events in the neutral wedge, since the necessary influence would in that case have to be transmitted with a speed faster than light. But, curiously enough this elementary notion of cause and effect is quite inconsistent with a strictly causal scheme. Eddington further puts:

"How can I cause an event in the absolute future, if the future was predetermined before I was born?". The notion evidently implies that something may be born into the w at the instant Here-Now, which has an influence extending throughout the Future Cone but no corresponding linkage to the cone of Absolute Past. In the primary Physics there is no such thing as time's arrow and hence there is no discrimination of cause and effect, but events are connected by a symmetrical causal relation which is the same viewed from either end.

Eddington, in the book, further mentions an example of a lever in a signal box. The dropping of the signal and the movement of the lever are not synchronous thereby creating a time interval. Assuming the system of lever and the signal a crude machine, the drop of the signal can also cause the movement of the lever in which case the *Reason* for cause and effect gets interchanged. I have used the word 'reason' as an appropriate word here and if one goes into details of the meaning of 'reason' and 'cause', one has to enter into the jugglery of dictionary. Eddington is, probably, the only author who has clearly distinguished 'causality' from 'causation'. He says that in the primary Physics distinction between cause and effect has no meaning and further argues that the relation of effect to cause as "causation" and the symmetrical relation which does not distinguish between cause and effect as "causality". In the primary Physics, causality has completely replaced causation.

3.2 The Views of Werner Karl Heisenberg (1901-1975) [6] and [7]

The German theoretical physicist, one of the pioneers of quantum mechanics and winner of the 1932 Nobel Prize, Werner Karl Heisenberg (1901-1975) (Fig.7) in his book titled, "The Physical Principles of Quantum Theory"[6] mentions that the chain of cause and effect could be quantitatively verified only if the whole universe were considered as a single system – but the Physics has vanished, and only a mathematical scheme remains. The partition of the world into observing and observed system prevents a sharp formulation of the law of cause and effect. (The observing system need not always be a human being; it may also be an inanimate apparatus such as a photographic plate.) As examples of cases in which causal relations do exist the following may be mentioned. The conservation theorems for energy and momentum are contained in the Quantum Theory, for the energies and momenta of different parts of the same system are cumulative quantities. Furthermore, the principal axes of q and time t are only infinitesimally different from the axes of q and time t + dt. Hence, if two position measurements are carried out in rapid succession, it is practically certain that the electron will be in almost the same place at all times.

To co-ordinate a definite cause to a definite effect has sense only when both can be observed without introducing a foreign element disturbing their interrelation. The law of causality because of its very nature can only be defined for isolated systems and in Atomic Physics even approximately isolated systems cannot be observed.

Heisenberg goes more philosophical in his second book, "Physics and Philosophy" [7]. This time, it is by the American philosopher and author of the most influential work, *"The Meeting of East and West",* F.S.C. Northrop (1893-1992) (Fig. 9) and who has given for Heisenberg an exhaustive 26 page Introduction in the book. Hence the credit of this part goes to Northrop rather than for Heisenberg. Northrop says: that Heisenberg's philosophy of Physics has an element in common with that of the English mathematician, philosopher and the defining figure of the school of process philosophy Alfred North Whitehead (1861-1947). According to Heisenberg, the concept of causality has two different meanings; one stronger than the other. He, however uses the word 'causality' for the weaker meaning and the word, 'determinism' for the stronger meaning. When the former usage is followed, the words, 'causality' and 'determinism' become synonymous. When the second usage is followed, every deterministic system is a causal system, but not every causal system deterministic. Heisenberg gives an example of a layman's common sense usage of the word 'cause' in this way that "A stone hit the window and caused the window to break". In this use of causality, it is thought of as a relation between objects. i.e. the stone and the windowpane. The scientist expresses the same thing in a different

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 4, Issue 11, November 2017

way: He describes this event in terms of the state of the stone and the windowpane at an earlier time t_1 when thye stone and windowpane were separated and the state of the same system of two objects at a later time t_2 when the stone and windowpane collided. Consequently, wheras the layman tends to think of causality as a relation between objects, the scientist thinks of causality as a relation between different states of the same object or the same system of objects at different times.

What Quantum Mechanics says about causality, we must consider two things: 1) the state function which defines the state of any physical system at any specific time t, 2) The Schrodinger time equation which relates the state of the physical system at the earlier time t_1 to its different state at any specifiable later time t_2. Heisenberg says (as quoted by Northrop) that the two must be read with meticulous care.

3.2.1 Causality and the S-Matrix [11] and [13]

To eliminate the difficulties of the quantum field theory and to correlate the same with cause and effect, Heisenberg in 1940 proposed a peculiar method with the formalism of a Scattering Matrix or S-Matrix. It is used in Scattering Theory, Quantum Mechanics and Quantum Field Theory. It is legitimate to know what it is and for which we seek the help of Wikipedia [13]. The S-Matrix was first introduced by an American theoretical physicist, John Archibald Wheeler (1911-2008) in 1937 and independently developed by Heisenberg in 1940.

Consider a localized one-dimensional potential barrier V(x) subjected to a beam of quantum particles with energy E and incident on the barrier from left and right. The solution of the Schrodinger equation outside the potential barrier are plane waves and is given by

$$\psi_L(x) = A\, e^{ikx} + B\, e^{-ikx} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

for the region to the left of the potential barrier and

$$\psi_R(x) = C\, e^{ikx} + D\, e^{-ikx} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

for the region to the right of the potential barrier where k is the wave vector given by

$$k = \sqrt{\left(\frac{2\,m\,E}{\hbar^2}\right)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

As the time dependence is not required, the same is omitted.

The term with the coefficient A denotes the incoming wave where the term with coefficient C denotes the outgoing wave. B stands for the reflecting wave. The wave coming from the left is taken as positive. As D is zero, it can be omitted. The "Scattering amplitude" i.e. the transition overlap of the outgoing waves with the incoming waves is a linear relation defining the S-Matrix

$$\begin{pmatrix} B \\ C \end{pmatrix} = \begin{pmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{pmatrix} \begin{pmatrix} A \\ D \end{pmatrix} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

The above relation can be written as

$$\psi_{out} = S\,\psi_{in} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

where $\psi_{out} = \begin{pmatrix} B \\ C \end{pmatrix}$, $\psi_{in} = \begin{pmatrix} A \\ D \end{pmatrix}$ and $S = \begin{pmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{pmatrix}$

The elements of S completely characterize the scattering properties of the potential barrier V(x)

Following the definitions given above, the square of the S-Matrix expresses the probability that a system of elementary particles will, from a system of remote time described by the wave function, say, $\psi_{-\infty}$ pass (at a distant future time) into a state described by the wave function, $\psi_{+\infty}$. Thus, mathematically equation (5) can be written as

$$\psi_{+\infty} = S\psi_{-\infty} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

keeping in mind the side where the particles getting out is taken as positive.

G.A. Svechnikov [11] adds: In one of the first variants of the S-Matrix, Heisenberg proceeded, in particular, from the assumption that at very small distances an action may be propagated from one particle to another with a velocity greater than that of light and if such a possibility happens to exist in the micro world, then from the natural assumption that under real conditions, the cause cannot follow the effect and for all such processes the Lorentz transformations are inapplicable. Consequently, the temporal sequence of cause and effect is maintained in all frames of reference. This statement of the causality condition is just an extrapolation of macroscopic causality to the realm of micro processes. In subsequent investigations Heisenberg acknowledged that the S-Matrix must not only be unitary and invariant.

Modern Quantum Physics does not reject the macroscopic concept of causality; it only deepens it, refines it and expresses more precisely than classical Physics the dialectical nature of the cause-effect relation; it lays here the significance of the concepts of necessity and chance, possibility and actuality in learning the objective causal connections of the micro world.

DOI 10.17148/IARJSET.2017.41115

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 4, Issue 11, November 2017

3.3 Views of David Bohm (1917-1992) [2]

David Bohm (Fig.10), one of the most significant American theoretical physicist of the 20th century and author of the treatise Quantum Theory has dealt with the problem of determinism and causality which have occupied a central position in all philosophical discussions since the time when man first tried to obtain a more complete general understanding of the world than is afforded by deduction from

Fig.9 F.S.C. Northrop (1893-1992)

Fig. 10 David Bohm (1917-1992)

Fig. 11 Sir Edmund Whittaker (1873-1956)

immediate experience. He begins with a brief account of the kinds of ideas on causality that man has held and shall show on what basis the modern ideas on the subject have been developed. Some of the most primitive ideas on cause and effect probably arose when man noticed that, by exerting various forces on his surroundings and by doing work, he could produce desired effects or avoid undesired effects. The most primitive notion of causality is, therefore, closely connected with mechanical concepts of force and work. Later, man came to know that the human body is made up of the same matter as inanimate objects. This led to the concept of inanimate causes. The ultimate effect is always not in proportion to the cause. According to him, the effect caused by material forces are only to be considered.

3.4 Views of Sir Edmund Whittaker: (1873-1956) [12]

The English mathematician, Sir Edmund Whittaker (Fig. 11) has also dealt with causality and determinism. He considers a physical system isolated from external influences meaning thereby that all events within the system take place causally. This is to assert that a knowledge of the state of the system at any instant is sufficient, in principle, to determine its state at any subsequent instant. The author ignores all metaphysical nonsense that has accumulated in this connection and touches upon molar physics and deals with occurrences where single atoms are involved. Whittaker further quotes Immanuel Kant who said quite justly that regularity in occurrences is a presupposition of the science of Physics. He (Kant) supposed (erroneously) that these regularities must always be the kind that we meet with in molar Physics namely that they must be deterministic as regards individual events, but this is not so. The regularities on which the science of atomic Physics is based are statistical regularities, and do not involve complete determinism

3.5 Views of Kitty Ferguson (b. 1941, Age 76) [8]

A really philosophical master piece, "*The Fire in the Equations"* [8] written by a famous American science writer, Kitty Ferguson (Fig.12) and in which the famous theoretical physicist, Stephen Hawking calls it as a "A clear account of the ultimate question". Ferguson says that - we also assume with no way of testing it that cause and effect operated at the very earliest stages of the universe. Even at the moment of creation? So strong is our belief that it is difficult to imagine that the universe itself could exist without a cause; that it could just BE. We want to know how it happened, and we want to find the answer to the question, "Why?" or even "Who". She further says:

Fig.12 Kitty Ferguson (b.1941, Age 76)

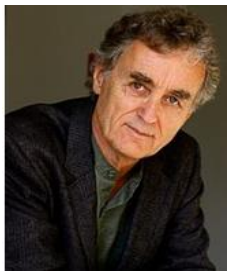

Fig. 13 Fritjof Capra (b.1939, Age 78

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 4, Issue 11, November 2017

Belief in cause and effect is a cornerstone of the scientific method. Nevertheless some scientists keep reminding us that the 'law' of cause and effect is an article of faith, not a law at all. It can't be proved to operate in all cases. Indeed there is a major subfield of modern Physics that requires us to reconsider our assumption that every event has an unbroken history of cause and effect leading up to it.

She further says that the rationality of the universe goes beyond the manifestation in obvious symmetry, pattern and cause and effect. It would appear to include the ability to make judgements as to when the symmetry must be broken, when the geometry must be pulled out of shape, when cause and

effect must not apply. Is that the rationality of the mind of God?. There is geometry hidden in nature. The way we see, the way we judge the distance and perspective is all bound up, with triangles and cones. The symmetry and geometry go deeper than what we most readily see in the natural world, the digression from ideal geometry and symmetry also goes deeper.

The author further continues: The mathematical and logical consistency itself is sometimes shaped by the way the universe is. Mathematical and logical consistency just is. The universe just is. We might suppose that the three First Causes are really one.- God. Mathematical and logical consistency and the universe existing in perfect unity – all defining one another. Short of such an unorthodox trinity, it seems one of the three must be uncaused First Cause, with no answer to the questions why or how.

Throughout the book she gives lot of causal arguments regarding existence of God.

3.6 Views of Fritjof Capra (b.1939, Age 78} [4]

The Austrian born American physicist, Fritjof Capra (Fig.13) in his popular book, *"The Tao of Physics"* [4] correlates cause and effect with Buddhist philosophy. According to him, cause and effect is something like 'action' creating 'action'. We are trapped, he says, in a vicious circle where every action generates further action and the answer to each question poses new questions. This vicious circle, in Buddhism is known as *"Samsara"*, the round of birth and death, and it is driven by '*Karma'*, the never ending chain of cause and effect.

In relation with a particle moving in space-time, the author quotes Louis de Broglie "In space-time everything which for each of us constitutes the past, the present and the future is given en bloc……Each observer, as his time passes, discovers, so to speak, new slices of space-time which appears to him as successive aspects of the material world, though in reality the ensemble of events constituting space-time exist prior to his knowledge of them". The author, further quotes Swami Vivekananda:

"Time, space and causation are like the glass through which the Absolute is seen……..In the Absolute there is neither time, space nor causation."

According to the author, in the principle of causality, energy and momentum are transferred over spatial distances only by particles, and that this transfer occurs in such a way that a particle can be created in one direction and destroyed in another only if the latter reaction occurs after the former. The mathematical formulation of the causality principle implies that the S-Matrix depends in a smooth way on the energies and momenta of the particles involved in a reaction except for those values at which the creation of new particles becomes possible. At those values, the mathematical structure of the S-Matrix changes abruptly. It encounters what mathematicians call as "Singularity". The fact that the S-Matrix exhibits singularity is a consequence of the causality principle.

IV NECESSITY AND CHANCE

4.0 The Russian book, ABC of Dialectical and Historical Materialism [1] mentions Necessity and chance are linked to the concept of cause and effect. Chance is commonly taken to mean that which might or might not occur or might occur in any way. Necessity, on the other hand, is understood as that which must occur and cannot but occur. For the interrelation between necessity and chance, there is nothing that necessarily must occur and nothing that might not occur. Anything, any event, however incredible may occur, and it may occur one way or any other way. From this point of view, nothing is impossible. There is no such thing as necessity. Everything in this world is the outcome of chance.

V THE CANONS OF INDUCTION AND THE LAW OF CAUSATION

5.1 The Canons of Induction:

Norman Robert Campbell [3] presents an exhaustive, philosophical and classical master piece in which he warns the reader at the preface itself that it is not a simple treatment. Few excerpts taken from the book includes the following:

An eminent philosopher, Mill along with Whewell, Hamilton and Jevons tell us in the expression, laws of nature that it is the uniformity which exists among natural phenomena which is the relation of cause and effect. The process of arguing from the particular to the general or from the small portion of experience of which we have knowledge or record to the much greater portion which is at the time wholly unknown to us, is generally called 'induction'. Those

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 4, Issue 11, November 2017

who have held the opinion concerning the importance of cause and effect in scientific laws also held that the problems of induction are to be solved by following certain definite rules of experiment and ratiocination. Mill termed these rules as *"Canons of Induction"*. By 'canon' we mean general law, rule, principle or criterion. The reader may note the spelling of canon. If we put double' n', say 'cannon' It is a war weapon. The canons of induction in the form given by Mill are all based on the assumption that the uniformity which is asserted by laws is the causal relation; it might seem therefore when once we reject that assumption, any further examination of the canons will be necessary. But an investigation would show that the assumption that all physical laws are causal is not really essential to the canons.. They profess to provide a meaning of establishing that a "fact" X is the cause of the "fact" Y but the method which they provide does not depend for its validity on the assumption that the relation of the cause to the effect is temporal or that it is symmetrical, it depends for its validity only on the assumption that the relation is dual and invariable. For the canons do not profess to prove that X is definitely the cause or definitely the effect of Y; almost they propose to prove that it is either the cause or effect, and sometimes they do not propose to prove even as much as that. Accordingly, they assume only that the relation X and Y has those characteristics which are possessed equally by cause and effect. While the canons of induction assume nothing about the logical form of the causal relation except that it is dual and invariable, but they certainly assume another very important proposition about causality. This proposition is the law of causation.

5.2 The Law of Causation:

The law of causation is involved inextricably in the canons and is sometimes stated in the form 'fact'that every effect has a cause. But, in this form the law speaks very little. By the law of causation it is meant that every 'fact' is an 'effect' and consequently, that every fact is related to some other by the causal relation. In this form the proposition will assert something significant if, and only if, we can give a clear and definite meaning to the term, 'fact'.

The fundamental idea implied from the word, 'fact' seems to be independence to some extent Of other facts. Experience is supposed to be divided into portions such that no portions contain anything in common. Each such portion is a fact. From the point of view of this definition, the law of causality as it is used in the canons can be paraphrased thus: Some or all of our experience of the external world can be divided into portions which contain no common part and are such that every such portion can be combined with some other portion to form a routine in which those two portions, or 'facts' are the terms related as cause and effect. A single fact can be combined successively with number of other facts to form a corresponding number of different routines. This number is generally related to two. That is, a fact can be combined with another fact as a cause and with a second other fact as an effect. The two routines are indistinguishable by the canons as they cannot tell the difference between cause and effect.

An analysis using common sense reveals that there is only one method of dividing experience into facts and it is really fundamental. Canons can undoubtedly lead to wrong conclusions if a wrong division into facts is made. The true fundamental facts are the ultimate elements into which experience can be divided, or that each elementary judgment is a fact. The division is said to be made correctly. The correct division involves the previous knowledge of all causal relations. Any division whatever of experience into portions which include no common part will give facts which are subject to the 'law of causation'. To sum up, and following Mill, one can say that: "*To certain facts certain facts do succeed. The invariable antecedent becomes the cause and the invariable consequent the effect".*

VI CAUSE AND EFFECT IN QUANTUM MECHANICS

The British science writer and editor of Journal, *Nature*, Philip Ball [10] in an article titled, *"How quantum trickery can scramble cause and effect?* He says the logic defying experiments in quantum causality can twist the motion of time itself. It seems to run in two directions at a time. Causation lies at the interface between Quantum Mechanics and General Relativity. At the quantum level the normal rules of cause and effect need not apply. Within the mathematical formalism of Quantum Theory, ambiguity about causation emerges in a perfectly logical and consistent way. Even the photons are considered as both waves and particles and events are termed as a haze of uncertainty.

Causation has been a key issue in Quantum Mechanics right from the EPR (Einstein-Podolsky-Rosen) thought experiment which according to Einstein leads to situation with velocity of particles becoming greater than that of light thus invalidating the theory of relativity and the Copenhagen interpretation.

Brunkner's group in Vienna, in order to explore this ambiguous causality in Quantum Mechanics, devised ways to create related events A and B such that no one can say whether A preceded and led to (in a sense 'caused') B. or vice versa.

In 2009, Chinbella and his team performed a thought experiment (Fig.15) using a single qubit as a switch that controls the causal order of events experienced by particle that acts as a second qubit. The researchers sent photons through a series of gates with an ambiguous causal order. The set-up is analogous to the movement of a cart through a pair of gates governed by a two-way switch corresponding to a qubit and following the route the cart takes. In the Fig .(a) if the qubit switch is set to position-0, the cart moves through gate A and then to

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 4, Issue 11, November 2017

Fig. 14 Philip Ball (b.1962, Age:55)

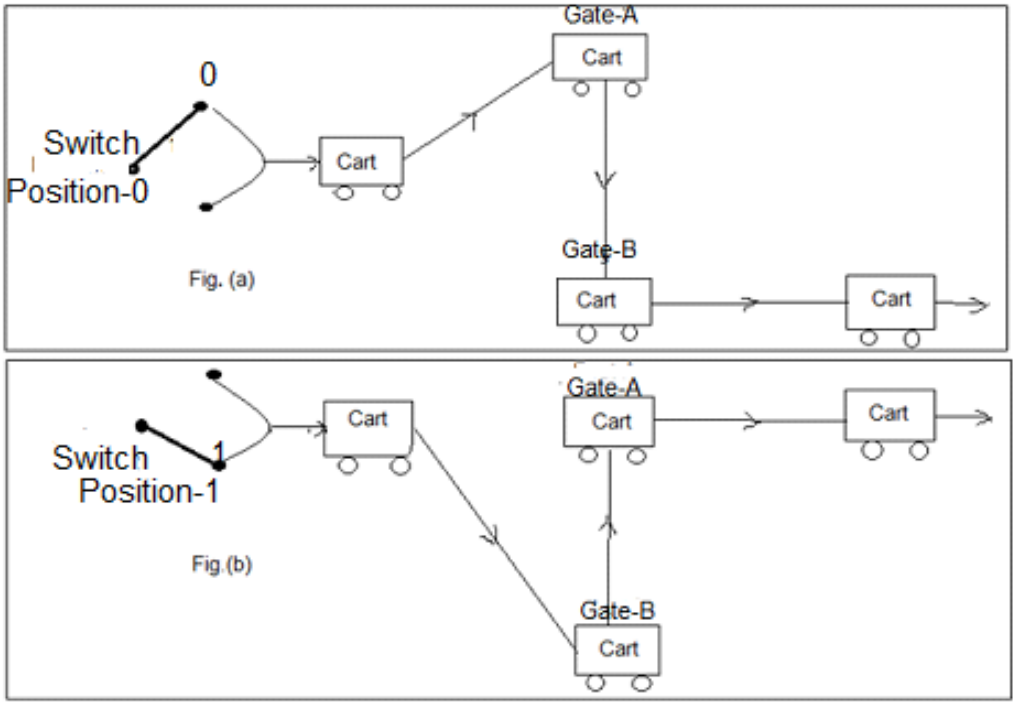

Fig.15 The Thought Experiment (modified by Author) given by Philip Ball [10]

gate B. This route has a definite causal order. Alternatively, the qubit can be set to position-1 as in Fig.(b). The cart then passes through gate B, and then to A, again with a definite causal order. Thus there is no definite order to the particle's traversal of the gates.

The framework of causal models prepared by the team help to further understand the entanglement of superposition

VII CONCLUSION

7.1 The Cause and Effect and Development of Physics:

The development of Physics has taken place by analyzing the effects in the search for the causes. What is needed is the right analysis of both the causes and effects which is generally not done. One would like to know whether the same or similar causes would lead to same or similar effects. If you cannot trace the cause for an already known effect, there is something wrong or lagging in the analysis of the effects. As an example, sometimes an earthquake occurs in a non-earthquake zone and the cause or causes for which may need rigorous analysis by well known geophysicists. In fact the entire theme of Physics is built on the causes and their effects.

7.2 Cause and Effect in general life:

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 4, Issue 11, November 2017

The cry of an infant is such an effect the causes for which are many and not known to any one and known probably only to its mother. Politicians have to keep close watch on various effects and ponder over the causes that created them. The mechanism of the human body is such that the effects are rhythmic so also are their causes. The causes for indication of fever in a patient can be many and the medical practitioner has to closely monitor various effects and investigate their corresponding causes in the diagnosis and treatment of a patient.

REFERENCES

[1] ABC of Dialectical and Historical Materialism, Translated from the Russian by Lenina Ilitskaya Progress Publishers Moscow, 1976, Ch.8, Sec.2, Cause and Effect, p.158-163.
[2] Bohm David, Quantum Theory, Asia Publishing House, Indian Ed. 1960, Ch.8, Sec.8 Early Ideas on Cause and Effect, p.148-149
[3] Campbell Norman Robert, Foundations of Science-Philosophy of Theory and Experiment, Dover Publications Inc. N.Y. 1957, p.57-67.
[4] Capra Fritjof, The Tao of Physics, Flamingo An Imprint of Harper Collins Publishers, 3rd Ed. 1991, ISBN 0 00 654489 4, p.108, 205, 305.
[5] Eddington Sir Arthur Stanley, The Nature of the Physical World, Comet Books 1928, Ch.XIV, p.239-247.
[6] Heisenberg Werner, The Physical Principles of the Quantum Theory, Dover Publications Inc. 1930, p.58, 63.
[7] Heisenberg Werner, Physics and Philosophy, Prometheus Books, 1999, Introduction by F.S.C. Northrop, p. 10-15
[8] Kitty Ferguson, The Fire in the Equations-Science, Religion and the Search for God, William B. Eerdmans Publishing Co. Grand Rapids, Michigan, Ed.1997, ISBN 0-8028-4355-7, p.12-16, 18-19, 125, 141-142, 267-70.
[9] Omelyanovsky M.E. Dialectics of Modern Physics, Progress Publishers Moscow, First Printing 1979, Ch.VI, Sec.2, Determinism and Principle of Causality in Physics, p.148-156.
[10] Philip Ball, A World without Cause and Effect, Nature-The International Journal of Science, 28 Jun 2017, p. 590-592
[11] Svechnikov G.A. Philosophical Problems of Elkementary-Particle Physics, Progress Publishers Moscow, First Printing 1968, Causality and Determinism in Microphysics, p.306-334.
[12] Wittaker Sir Edmund, From Euclid to Eddington, Dover Pub. N.Y. 1958, Sec.56, Causation And Determinism in Quantum Mechanics, p.157-159.
[13] Wikipedia, Edited on 7th Aug. 2017
[14] Yavorsky B. and A. Detlaf, Handbook of Physics, Mir Publishers, Moscow, 1972, p.536-7

BIOGRAPHY

*__Dr.(Prof.) V.C.A. Nair__ (b.15th Aug. 1939) is an Educational Physicist, Counselor, Research Guide and Consultant. He did his Masters in Physics from Mumbai University, India and Ph.D. from JJT University, Rajasthan also in India He is a Research Guide and distinguished alumni of JJT University. He is also a Chancellor designated Resource Person in the area of Physics in the University. He has to his credit over 4 decades of teaching Applied Physics in eminent Polytechnics in Mumbai and having taught nearly 16,000 students since 1965. He has published a number of research papers in Physics and Geophysics in International and UGC recognized Journals some of which can be seen in the net 'Google Search' when the name of the author is typed in that style. He is a Life Member of Indian Society for Technical Education which is an all India body. He had been to USA a number of times and visited eminent Universities such as Stanford, Harvard, MIT, University of California both at Berkeley and Los Angeles and University of San Francisco. At present Dr. Nair is a Research Guide for Physics at JJT University, Rajasthan-333001, India . He is member of the Editorial Board of this Journal. His Ph.D. Thesis is in Geophysics and he is working on topics such as Tides, Clouds, Global Warming and Climate Change. – Editor.
*nairvca39@gmail.com.