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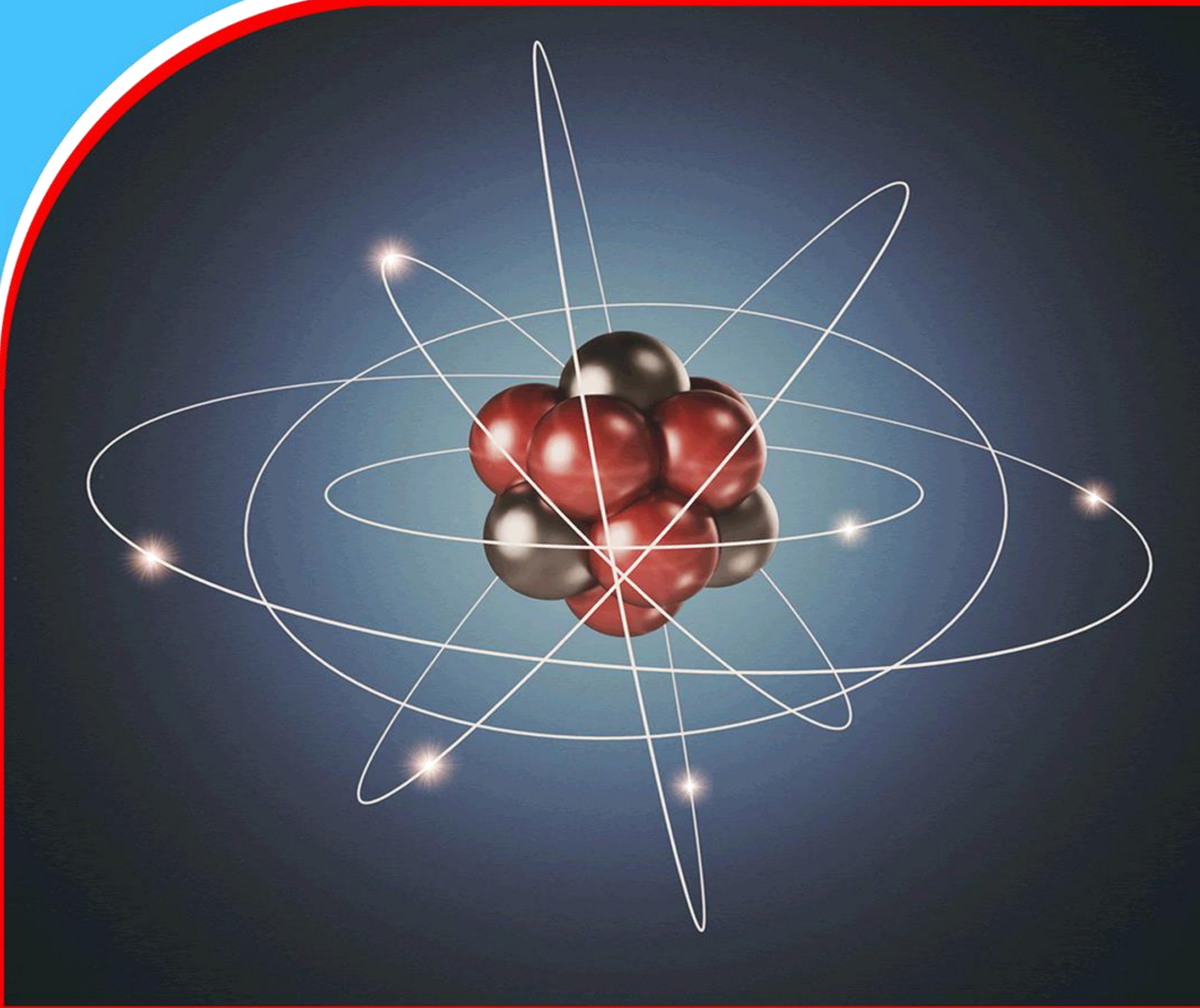

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Popper's Propensity Interpretation of Quantum Physics as a Form of Modal Metaphysics

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Abstract

With the emergence of quantum physics in the 1920s, the major philosophical question was, do the unobservables in quantum system have ontological status or are mere instruments for scientific prediction? The Copenhagen interpretation developed an instrumentalist thesis, contending that the unobservables are tools for making predictions concerning the observables. Thus, we cannot have knowledge of the quantum particles. However, Popper attempts a realist and an objective interpretation. As such, he criticizes the Copenhagen interpretation, developing the propensity view, which accords ontological status to subatomic particles. The main thrust of our argument in this paper is that by replacing probability possibilities with propensities, Popper positions himself as a proponent of the metaphysics of modality. It is then our objective to establish the parallelism between Popper's Propensity Interpretation and Modal Metaphysics. To establish this contention we proceeded analytically: firstly by situating the seismic shift from macro to quantum physics, secondly by examining Popper's critique of the Copenhagen Interpretation and thirdly by attempting a demonstration of the correlation between Popper's propensity interpretation and modal metaphysics. The merit of this paper resides in its elucidation of the importance of metaphysics in science. It is a double challenge at the same time for antimetaphysical philosophy of science and for antiscientific metaphysics, to rethink the relationship between Metaphysics and science and invest in finding how both disciplines nurture each other. Finally, it is hoped that policy makers in Philosphy and science uses our findings to revamp the conceptualisation and practice of interdisciplinarity.

Keywords: *Instrumentalism, Realism, Quantum Physics, Unobservables, Metaphysics of Modality and Propensity*.

1.0 INTRODUCTION

Science is refers to human intervention on nature using instruments to explain and predict how nature functions. Physics is an archetypical and paradigmatic experimental science because of its systematic study of material structures and constituents of our observable universe. To render science a reliable human tool, it is incumbent to ensure efficiency in scientific theorisation and precision in prediction. Even though macrophysics took the challenge to erect their explanatory models on determinism with efforts to attain exactitude, the advent of quantum physics harbingered indeterminism and imprecision for laws of macrophysics could not account for the behavior of the unobservables such as protons, positrons, and neutrino. With the orientation of physics to the subatomic states, there was a transition from induction to probability. The consequential muddle in physics then was to find out if the microphysical particles like the wave had independent existence from the particle. While the members of the Copenhagen school like Heisenberg and Bohr are instrumentalists in their answer, Popper rejects instrumentalism and proposes a realist interpretation. We will not only highlight the major revolutions that led to the advent of quantum physics, but we shall present the Copenhagen interpretation to Popper's critical tribunal. Finally, the originality of our approach will consist in showing the symmetry between Popper's propensity interpretation and the metaphysics of modality.

The Rupture from Macrophysics to Quantum Physics

In the first place, determinism and precision are the major axes of macrophysics. Macrophysics in this multi-faceted coloration as in theoretical cosmology, speculative astronomy, physical astronomy, atomism and mechanism is grounded on the postulate of determinism. The history of macrophysics which is the chronicle of the ruptures that took place in the study of matter, the atomic structures and the universe emerged from natural philosophy of the ancient Greek philosophers. This is because the latter were the first to carry out conscious inquiry into nature. To Gottfried Heinemann, "in the early Greek tradition, talking of something's nature (phusis) is generally a way to describe the outward characteristics of the thing." (Heisenmann et al., 2020: 3). Even though the Babylonian and Egyptian astronomers documented ample and precise data on the perceptible positions of heavenly bodies, our focus is on the western archeology of physics.

The pre-Socratics confuted mythology proceeding to the distinction between the natural and the divine world. The natural universe became the object of study and thus, could be comprehended using the powers of the intellect. The aims of their physicalism were to observe, conjecture, generalize and explain the physical causes behind the visible order in the universe. As Weiner Heisenberg, contends, "The idea of the smallest, indivisible ultimate building blocks of matter first came up in connection with the elaboration of the concepts of matter, Being and Becoming which characterised the first epoch of Greek philosophy." (Heisenberg, 1958: 26). According to the Ionians, material objects are composed of a variety of particles such as water, air, fire and earth. The Eleatics refuted the pluralism of the Milesians as a product of sensory illusion. To Parmenides, Being is one and as such, there is no empty space to host change. This position was refuted by Empedocles who in his pluralism conjectured that in the formation of the earth, there should have been an infinite realm of the one. This unity to him should have been a product of the fusion of the four basic elements (earth, water, are and fire). Anaxagoras equally readopted the idea that all change is caused by mixture and separation. He took a step toward atomism by postulating the infinitely small seeds as the basic units of all. These seeds change in number and in relative positions. Motion in Anaxagoras' universe is generated by the 'nous', which is the mind. In the atomism of Democritus, Being is not one, for "it can be repeated an infinite number of times." (ibid., 1958:31). Thus, atoms are infinite, uncreated and smallest units of matter. Unlike Parmenides who rejected the idea of the void, Democritus hypothesized the existence of the voids that is, the empty space where atoms move. This follows that, space is not nothingness for it has geometric and kinematic values.

In the post-Socratic natural philosophy, Plato initiates a change from atomism to geometry, due to the influence of the five regular solids of Pythagoreans. Mathematical forms to Plato constitute the smallest parts of matter. To Plato, the Demiurge or creator used mathematical forms to create the four elements postulated by Empedocles. He thus avows that "finding them in that condition, then, the first thing the god did, when he came to organize the universe was to use shapes and numbers to assign them definite forms […]The starting point is, of course universally accepted: that fire, earth, water and air are material bodies. Now, this means that like all bodies, they have depth, and anything with depth is necessary rectilinear surface consists of triangles." (Plato, 2009: 46). Aristotle adopted the four elements from Plato but hypothesized an antivoid; aether, which has the four physical sensations of hot, cold, dry, wet, and can be used to account for everything. There is no void to him and movement is a locomotion for elements have the disposition of regaining their natural places. To Aristotle, "each body when not prevented moves to its own place, up, down." (Aristotle, 1936: 370). The Earth being the heaviest is at the centre, oceans are on top of earth because water is lighter than the earth, air is above water and fire is above air. The earth to him is then round and the centre of the universe and celestial bodies are perfect circles and move round the earth. Descartes rejects the natural account of motion by Aristotle and argues that motion is a product of collision between parts of matter. He grounds this thesis on the three laws of motion. In the first law on the conservation of momentum, Rene Descartes states that "each part of matter always continues in the same state unless collision with others, forces it to change its state." (Descartes, 2004: 25) In the second law, he states that force is proportional to acceleration and in his third law on action, reaction equivalence, he holds that when a body collides with another that is stronger than itself, it conserves its motion but loses quantity of its motion if it collides with a weaker body. Rejecting the notion of the void then, Descartes sets the pace for mechanics. To Leibniz, the fact that bodies do resist penetration during pushing implies the existence of repulsive forces in objects. Matter to him then can simply be reduced to forces, constituting space. These forces to him arise from monads and not from space.

The apogee of classical physics is epitomized by the mechanics of Newton. However, as Roland Omnès retorts, "before him (Newton), these laws appeared merely as empirical rules, extracted after careful analysis from the mass of facts. But Newton introduced principles, universal laws that nature obeys, and from which the former empirical laws follow as logical mathematical consequences." (Omnès, 1999: 31) These laws are applied in absolute space and time. Absolute space is not a property of the earth for its existence does not depend on its relation with other things and absolute time on the other hand is mathematical time that exists by itself. . Even though Newton does not cite Descartes in his Principia, the former's three laws of motion are a re-appropriation of Descartes laws His first law of motion is a derivative of Descartes and Galileo laws of inertia. According to this law, a body at rest remains so unless acted upon by an external force and a moving body continues in the same direction, at constant velocity unless acted on by a force. It is possible then to determine the velocity and position of objects, whether at rest or in motion. In the second law, Isaac Newton (Newton, 2016: 62) asserts that, "a change in motion is proportional to the motive force impressed and takes place along straight line in which that force is impressed." Given the mass of a body and the force acting on it, this law permits the calculation of the rate of change of velocity. According to Newton's third law, "to any action there is always an opposite and equal reaction." (Ibid; p. 63) The first law states what happens to the object in the absence of a net force, the second law states what happens to an object when there is net force and the third law determines the type of force existing between objects. Thus, from the second and third law, Newton did not only infer Kepler's laws from his but he went beyond Kepler to propose the universal law of gravitation in which he precised that objects attract each other by virtue of their masses. This attraction is not only proportional to the product of masses between two objects but it is also inversely proportional to the square of the distance that exist between their centers. With Newton, laws of motion and gravitation, all physical processes such as falling bodies, planetary motions, collision and vibrations of strings could be determined, predicted or explained.

The advent of quantum physics challenged the search for precision that animated classical physics. The Newtonian scheme set the basis for objectivity, determinism and precision in every aspect of scientific investigation on matter such as astronomy, mechanics and thermodynamics. That is why Giampiero Esposito notes that by the first half of the 19th century, "Newton, Lagrange, Hamilton, Jacobi and Poincaré, the Maxwell theory of electromagnetic phenomena and the laws of classical mechanics could account for all known physical phenomenon." (Esposito, et al., 2004: 3) However, the early 20th century witnessed the development of two key revolutions; Max Planck's thermodynamics and the quanta hypothesis of 1900 and Einstein's special relativity (1905) that he generalized in 1915 to account for the behavior of the physical reality as a whole.

Using three basic laws that Peter Atkins summarizes into the laws of conservation of energy (first law), the increase in enthropy, (second law) and the approximation constancy of the enthropy of a system when temperature approaches zero, (Atkins, 2010: 92) classical thermodynamics was able to explain the electromagnetic fields. However, it could not explain an anomaly. This was the so-called ultraviolet catastrophe. The problem then was to explain why black bodies radiate in given temperatures at specific wavelength with corresponding intensity. A black body in this context refers to any object that absorbs all forms of energy. The need to understand and predict the exact relationship between temperature wavelength intensity was a serious challenge to classical thermodynamics. If we consider the first law of classical thermodynamics, expressed by Peter Atkins as "energy can be neither created nor destroyed", (ibid, 16) the implication will not only be the positing of the law of the conservation of energy but also the view that energy is continues. In other to solve the ultraviolet catastrophe, classical thermodynamics used the same hypothesis. That is they predicted that intensity will continue to increase as the wave decreases and will even become infinitely large. This hypothesis was not tenable because if energy is continues then the world and other electromagnetic systems could have produced blasts due to infinite explosion of energy.

The classical thermodynamics collapsed when Max Planck published the theory of blackbody radiation. As A. C. Phillips, affirms, "Planck provided an explanation of the observed properties of black body radiation by assuming that atoms emit and absorb discrete quanta of radiation with energy." (Philippe, 2003: 1) In classical thermodynamics, heat is the transfer of energy from one place to another but in the quantum models, it is the atomic vibrations that cause light. To Max Planck, "the whole problem amounts to the determination of the temperatures corresponding to a monochromatic radiation of a given intensity." (Planck, 1914: 151) However, Max Planck observes that, "for all conceivable distributions of energy, the normal one, that is, the one peculiar to black radiation, is characterized by the fact that in it, the rays of all frequencies have the same temperature." (id) Since Oscillators are stationary, Planck notes that they do not only absorb heat but they also emit it. This leads to Planck's pronouncement of the hypothesis of the quantification of energy. This is because the emission of heat "does not take place continuously, as does the absorption, but that it occurs only at certain definite times, suddenly in pulses," (ibid: 167). Energy emitted by black bodies is, not then continues but it discrete quantities called the quanta. Thus, the thermodynamic system necessitates a seismic shift from induction to statistical method. Planck then adopted statistics as, he observes that, "the processes which cause the emission will be assumed to be of such a concealed native that for the present, their laws cannot be obtained by any but statistical methods," (ibid: 167). This hypothesis with accompanying laws and formulas were used to calculate the radiation of black bodies. It thus ushered in a new era in physics; the birth of quantum or subatomic physics.

The second major revolution in physics in the 21st century is the Einstein's theory of relativity. Though Newton's theory was used for over 250 years, it had so many oddities, as Jian Wang points out that "astronomical observations found that Mercury's orbit around the sun revolve against the clock, and the orbit is closed, this is the procession of Mercury. The procession of Mercury's perihelion calculated by Newton's law of universal gravitation is not consistent with the observed value." (Wang, 2021: 1) While all planet obit the sun in ellipse, in conformity with Newton's gravity, the behavior of mercury was a counter example to newton's scheme. It was as if the ellipse of mercury was orbiting the sun and its ellipse was never closing. This was later explained using Einstein's theory of general relativity. In his special relativity which applies to motion at constant velocity, Such motion is relative to a referent-body. Albert Einstein illustrates this, as he affirms, "(a) the Carriage is in motion relative to the embankment; (b) the embankment is in motion relative to the carriage." (Einstein, 2006: 57) In the theory of general relativity, Einstein equates gravity to acceleration. In his thought experiment, he came to a conclusion that whether in space where gravity is lower or on earth where it is higher, measuring the height of a beam of light reveals the same results. That is, whether on earth or in space, the height on the other side of the spectrum always appear to curve downward. This shows that light does not travel in a straight line and that the shortest distance between two points is not a straight-line, given the curving effect of light. This propelled Albert Einstein to state the principle of general relativity in the following words, "the geometrical properties of space are not independent but determined by matter." (ibid, 103) Space then is neither absolute nor is it immovable. In the presence of mass and energy, space becomes curved. Unlike the absolute space of Newton and the perfect geometry of Euclide, Albert Einstein states that, "as regards geometry, our universe behaves analogously to a surface which is irregularly curved in its individual parts, but which nowhere departs appreciated from a plane: something like the rippled surface of a lake." (id.) Gravity is not a mysterious force acting between the mass of two different property of space. It is simply the interaction between space and massive objects. There is then an inverse relation between matter and space – time for space/time is the geometric spectrum where matter moves while matter also has the ability to cause space-time to curve. If the speed of light is to be constant as purported by special relativity, then in gravitational field, time should pass slowly. Thus, time itself is not absolute.

Einstein's general theory of relativity was another revolutionary scheme that crumbled Newtonian physics. Not only did the new curve theory solve the problem of the prediction of the precession of mercury, but also Arthur Eddington confirmed it four years later. In solar eclipse, Eddington took photographs of stars near the sun and realized that as light passed near the sun, it was bent by space curvature due to gravity. Unlike Max Planck whose theory set the conceptual basis of the quantum theory, Einstein's theory instead created more riddles for the quantum theory. Some of these problems included the quest to know what gravity actually is, the nature of the connection between mass and space-time that causes curvature and the discovery of the concentration of mass to infinity of points. These two revolution shattered the precision of the age-old macrophysics, initiating new era, which consisted in using probability to interpret how these quantum states, particles and phenomena behave.

The Copenhagen's Interpretation in Popper's Critical Tribunal

With the advent of quantum physics, the idea of causality became outdated. Werner Heisenberg asserts that this was inevitable for, "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." (Heisenberg, 1930: 63) There is no way one can intervene on subatomic particles without influencing their nature in a particular way. Even if that were possible in quantum physics, it will only be effective in isolated systems. However, it is impossible to observe isolated systems. Quantum physics deals with entities and W. Heisenberg insists, that "there exist no infinitesimals, by the aid of which an observation might be made without appreciable perturbation" (Id). That is, we cannot talk of the independence of the object from the subject because every attempt by humans to study the subatomic states always alter the configuration of the latter. C.I.J.M Stuarts (Stuarts, 1991: 59) refers to this as the "principle of inseparability" which translates the union between the object-system under investigation and the subject or experimental apparatus. Tatyana P. Shestakova (Shestakova, 2020: 3) refers to it as "the principle of wholeness" as we cannot effectively separate the quantum object from the measuring device. As Louise de Broglie asserts, unlike, "in the old mechanics we consider particles or corpuscles as having a definite position in space" (1930: 12). The quantum particles exist as wave function and can only be studied using probability.

The Copenhagen interpretation also articulates on the notion of particle wave duality. According to De Broglie, particles before experiment exist as probability waves. This is called the principle of superposition. However, when an experiment is applied on an atom, the wave function collapses to one state leading to the detection of a particle. The problem that the Copenhagen school sought to solve then is that of the absence of precision in our attempt to comprehend the quantum system. W. Heisenberg grappled with the problem by proposing the principle of uncertainty which, "refers to the degree of indeterminateness in the possible present knowledge of the simultaneous values of various quantities with which the quantum theory deals; it does not restrict, for example, the exactness of a position measurement alone or velocity measurement alone." (Heisenberg, 1930: 20) If velocity of an electron for instance is known with exactitude and the position is totally unknown, Heisenberg reiterates that "every subsequent observation of the position will alter the momentum."(id.) This is because "every experiment destroys some of the knowledge of the system which was obtained by previous experiment" (id.). As Louis de Broglie reiterates "the better the position of a particle is defined, the larger is uncertainty about its state of motion and conversely." (De Broglie, 1990: 19) Faced with this dilemma, Niels Bohr proposes the principle of complementarity. That is, with the rejection of stationary state, space-time coordination and causality also vanish. Thus, with the principle of complementarity, a single quantum can exhibit mutually exclusive but complementary aspects like velocity and position and wave and particle duality. To Bohr, "when due regard is taken of the complementary feature required by the quantum postulate, it seems in, fact possible with the aid of the symbolic methods to build up a consistent theory of atomic phenomena, which may be considered as a rational generalization of the causal space-time description of classical physics." (Bohr, 1961: 87), In all, the Copenhagen interpretation opened the wide doors to instrumentalism, for the unobservable have no mind independent and stationary existence and they are simply tools for making prediction. The Copenhagen interpretation is then based on the principles of superposition, wave-particle duality, correspondence between classical and quantum mechanics, the completion postulate, the uncertainty principle, the principle of complementarity and the probability interpretation of wave functions.

The first argument that Karl Popper mobilizes against the Copenhagen interpretation is, on the principle of wholeness, which asserts the interdependency between the observer, or measuring apparatus on the hand and the object on the other hand. This principle to Popper amounts to saying that the quantum reality is created by consciousness for it attempts to illustrate that it is only through experiment that a wave can take the form of the reality. Such position to Popper orientates physics towards psychologism and subjectivism. To Karl Popper taking the Copenhagen interpretation seriously implies that the "objective reality has evaporated and quantum mechanics does not represent particles, but rather our knowledge, observation or our consciousness." (Popper, 1982: 3).

The second argument of Popper against the Copenhagen interpretation is an attack on the justification of the origin of probability in quantum physics. To Don Howard this controversy implicit in the Copenhagen interpretation arises from their attribution of probability to the "quantum mechanical limitations on our knowledge of the properties of atomic systems and thus ascribes a subjective interpretation to quantum mechanical probabilities." (Howard, 2012: 35) He however notes that, "Popper on the other hand, traces the probabilistic character of quantum mechanics to the statistical character of its problems." (Id.,). To Popper, every problem has its nature and context of emergence, a fortiori, the solution to any problem demands the identification its nature. This is what makes constitutes the critical situation of a theory. Popper remarks that the problem of quantum physics is of statistical nature and thus warrants statistical solutions. As such, lack of knowledge could not be a solution to a problem, for it was the latter and not the former that motivated the development of statistical theories. Popper thus holds that it is the attempt to "explain the probabilistic character of quantum theory by our allegedly necessary lack of knowledge rather than the statistical character of our problems, which has led to the intrusion of the observer or the subject into quantum theory." (op.cit, 50) The third criticism against the Copenhagen interpretation is on their confusion between theory and concept, which has made anti-realism to have an urge over realism in their philosophy. To Popper, "what we are seeking in science are true theories, true statements, and true descriptions of certain structural properties of the world we live in" (ibid: 42). That is, besides the predictive role, scientists are interested in objective truth, approximation to the truth, explanatory power of solving problems and in understanding the world. The Copenhagen dismissed every attempt by humans to make a coherent description of the world for quantum aspects are used as tools for predictions. This to Popper is because of the confusion between theories and conceptual framework in their system. They notoriously speak of 'particle picture' or 'wave picture'. If we take pictures for concepts then pictures cannot stand for theories. Popper then insists that "a theory is not a picture. It needs to be understood by the way of 'visual' images. We understand a theory if we understand the problem, which it is designed to solve it better, or worse, than its competitors. Thus, to assert that we cannot understand quantum theory as the Copenhagen does is to assert that we are not cognizant of the problem which it is designed solve.

The Rapprochement between Popper's Propensity Interpretation and Metaphysics of Modality

Popper's interpretation of quantum physics is a form of realism. Scientific realism is a theoretical framework, which holds that, "the reliability and credibility of science reside in the abilities of theories true descriptions of the world, (D. Basilis and N. Shang, 2022: 53). Popper notes that, what we attempt in science is to describe and (so far as possible) explain reality. We do so with the help of conjectural theories; that is, theories which we hope are true "or near the truth." (Popper, 1974: 40) Besides realism, Popper also defends an epistemology of objectivity. According to Popper "objectivity in the sense of empirical science is in principle only conferred on testable (that is, intersubjectively testable) observations." (Popper, 2009: 178). It is then our aim in this section, to show how Popper's interpretation of quantum physics, suits into the frameworks of objectivity and realism.

The first challenge Popper has to overcome to make a realist interpretation is to show how entities postulated by the quantum theory are real and the manner in which they can be objectively known. To realize this task, he makes recourse to Albert Einstein, Boris Podolsky and Nathan Rosen (the EPR) thought experiment. The EPR in the principle of completeness states that every theory has an objective reality. To them, "every element of the physical reality must have a counterpart in the theory." (Einstein et al, 1935: 777). Unlike the uncertainty principle of Heisenberg and the complementarity principle of Bohr, which hold that we cannot have an inclusive measurement of conjugate coordinates like position and momentum, the EPR asserts that, "it is possible to assign two different values to the same wave." (ibid, 779) In their entanglement theory, a quantum system having zero angular momentum, that is spin zero and emits two photons simultaneously can be studied objectively. Given the wave function of a composite system, by measuring the position of the particle A, we can infer the position of the particle B. This thought experiment motivates Popper to assert with the EPR "B must have an objective reality apart from an act of observation and it must have a sharp position and sharp position and momentum at the same time, even though we cannot know both at the same." (Popper, 1982: 19)

Karl Popper's propensity interpretation is a readjustment of the classical view. The classical view considered "P (a, b) to be the proportion of equally possible cases compatible with event b which are favorable to the event a." (Popper, 1982: 67). That is, the probability of favorable possibilities divided by the number of all equal possibilities. Popper however notes that if different weights are given to the possibilities, then the classical theory will collapse. He thus replaces possibilities with weights of possibilities. The weight of the possibilities is the measure of the propensity to realize itself upon repetition. Everything being equal, Popper asserts that the constant repetition of cases will turn the propensity or tendency towards stability. There are then weighted possibilities which have the tendency to become real. Tendencies are inherent in every possibility and are like forces that render statistics stable. This is an objective interpretation for, "propensities, it is assumed are not mere possibilities but are physical realities", (Popper, 1955: 12). Popper creates an equivalence between propensities on one hand and forces and field of forces on the other hand. Mathematically, when the probability is 1, it implies certainty, O is impossibility and ½ is indeterminacy. In physical propensities, 1 is "a special case of classical force in action: a cause when it produces an effect" (id) when there it is less than 1, it supposes the existence of competing forces, "pulling in various opposed directions but not yet producing or controlling a real process" (id). When the propensity is zero, it simply means the absence of propensity. Propensities are real and only the propensity interpretation guarantees the relationship between the macroscopic and the microscopic world. Popper notes that, "propensities in physics are properties of a whole physical situation and sometimes even of a particular way in which a particular situation changes. And the same holds of propensities in chemistry, in biology, and in biology" (Ibid, p. 17) Popper's interpretation illustrates the continuity between the microscopic and the macroscopic realms of the real.

The last question to grapple with now is that of the rapprochement between the propensity interpretation and modal metaphysics. Modal Metaphysics as conceived by Mark Sinclair deals with notions such as, "possibility and necessity, together with the notions of impossibility and contingency". (M. Sinclair et al. 2017: 1) Modal metaphysics then seeks for the truth-conditions of statements bearing such notions. Necessity refers to something that must be the case; e.g., 'a husband is a married man'. Necessary statements are tautological. Contingency refers to a situation that could have been or fail to be the case. Possibility implies that it could be the case and impossibility implies that it could not be the case. Orienting metaphysics to modality amounts to a break away from speculative metaphysics, representing the actual world as one of the possible. If the actual world is just one of the possible worlds then scientific hypotheses and the unobservables are possibilities that can be actualized when the means of experimentation are optimized. According to David K. Lewis, the first postulate of the metaphysics of modality is the thesis of the plurality of worlds. To him, "there are ever so many ways that the world might be; and one of these many ways is the way that this world is" (Lewis, 1986 : 2). The defense of the plurality of worlds is called modal realism. Lewis then equates the metaphysics of modality to modal realism as he asserts that, "I advocate for the thesis of the plurality of world or modal realism, which holds that our world is but one world among many" (id.,). Lewis proceeds to offer a utilitarian argument for holding such position. To him, the many-worlds theory is reliable and true because, "the hypothesis is serviceable and that is the reason to think it is true" (ibid. 3). For instance, as mathematicians use set theory, axioms and primitives believing they are true, so too do philosophers have the logical space; that is, the space of possibility. Philosophers in Popper's epoch made use of this logical space, even though they did not equate their projects to the metaphysics of modality. For instance, A.J Ayer, differentiates between practical verification and verification in practice. A.J Ayer illustrated this in the statement, "there are mountains on the farther side of the moon", (Ayer, 1936: 17), which cannot be verified practically but it is verifiable in principle. Implying that given the necessary heuristic means, we may one day verify it. To Russell, existence is a class of possible things and to Moritz Schlick, "verifiability means possibility of verification" (Schlick, 1936:41). There is then a possible world of science where man can accede with the development of appropriate and sophisticated experimental means. However, Ayer and Schlick did not pay attention to the relationship between verifiability and modality, given their positivist inclinations and their anti-metaphysical motivations.

The first moment in Popper's metaphysics of modality is his argument against historicism in social sciences. Historicism refers to those social theories, which hold that there is a fixed pattern for human history. To Popper, human history is shaped by the growth of human knowledge. Given that it is impossible to predict the future growth of knowledge using scientific methods, Popper contends that we cannot also predict the pattern of human history. Karl Popper attempts a proof for this by asserting that, "no scientific prediction-whether a human scientist or a calculating machine can possibly predict, by scientific methods, its own future results", (Popper, 1957: X) for such results can only be attained after prediction and verification had taken place. Popper equally criticizes rigid determinism in science as, "determinism is not a necessary prerequisite of a science which make predictions." (Popper, 1947: 81). Conceding to determinism implies that, "the scientific treatment of society and scientific predictions, are possible only in so far as the society is determined by its past" (ibid, 97) and this amounts to saying that science is of the domain of necessity, a position which contradicts the postulation of the possible.

The propensity interpretation of Karl Popper is grounded on indeterminism, which asserts that the past may be closed but the future is absolutely opened. Given that, propensities are dispositional properties and can be measured using conjectured potential or virtual frequency, Situations and possibilities are not determined for they change over time. The more our knowledge of the world grows the more situations and possibilities change. Popper thus reiterates that, "our very understanding of the world, changes the conditions of the changing world, and so do our wishes, our preferences, our motivations, our hopes, our dreams, our phantasies, our theories." (Popper, 1955: 17). The ephemeral nature of Physical and psychological past situations role out determinism, rendering the future opened. Thus, Popper infers form the preceding development that, since we do not know the future, "the future is objectively not fixed. The future is open: objectively open. Only the past is fixed, it has been actualized and so, it has gone" (ibid: 18). Thus, the future is just one of the possible Worlds cognized by science. This is therefore a strong case for the metaphysics of modality. Popper ingeminates this thesis by affirming that, "the present can be described as the continuing process of actualization of propensities" (id). Propensities are processes that are yet to be realized. Thus, there is no rigorous determinism and the world is a process.

Popper cites examples in physics and chemistry to illustrate his claim. In chemistry, he notes that, "every new compound creates further new compounds to synthesize: possibilities which did not exist" (ibid: 19). The space of zero that is, the possibility space is in constant growth. All non-zero possibilities will certainly realize themselves in time if there is a constant repetition of frequency. Thus, Popper contends that, “the future in this way, actively present at every moment” (ibid: 20). There are also illustrations in physics for Popper’s propensity interpretation. In 1932, positron and neutron were predicted. Even when Pauli announced the discovery of positron in 1933, Bohr, Heisenberg, Shrödinger, Eddington and some physicists were reluctant to accept it. Also, in “1934, Hideki Yukawa predicted the existence of mesons which determined the forces acting in the atomic nucleus and it was discovered in 1947 by Cecil Powell” (Brandt, 2009: 299). To resolve the radioactive beta decay conundrum, neutrinos were “Predicted by Wolfgang Pauli in 1930, it was only detected in 1956, when Fredrick Reines and Clyde Cowan captured neutrinos that had been produced in a nuclear reactor” (Bunch & Hellemans, 2004: 703). However, the mass of neutrino and its possibility of interaction were not known, as the former was qualified as a “ghost particle”. However, in 1998, it was discovered that neutrino had little mass, in 2010 the possibility of interaction between different families of neutrino were discovered and in 2015 Takaaki Kajita and Art McDonald discovered the mass of neutrino. These illustrations, tie with Popper’s contention that every new particle creates many possibilities or propensities of inventing new ones. If the unobservable were mere tools of predictions as the Copenhagen interpretation purported, then the discoveries would not have been possible. Karl Popper’s interpretation has not been given the attention it deserves by philosophers of physics. For instance, Pieter E. Vermass presents Van Fraassen (1972), Healey (1989) and Bub (1992) as the precursors of the modal interpretation of quantum physics (Vermass, 1996 : 5) while Jan Phillipp Dapprich and Annika Schuster project Van Frassen as the progenitor of the modal realism (Dapprich & Schuster, 2016: 78). Thus there is need to widen research on the symmetry between Popper’s propensity interpretation of quantum physics and the modal realism and metaphysics. The idea of propensities as real weighted possibilities is not only developed in, A World of Propensities (1955) and in, Quantum Theory and Schism in Physics, The Postscript to the logic of Scientific discovery (1982). This is because Popper announced his propensity interpretation as far back as in 1938 as a replacement of the frequency interpretation of quantum physics. This change is explained in the 1953 edition of The Logic of Scientific Discovery, specifically in footnote 1 of section 57. At the macrophysical level, Popper’s theory of propensities or weighted possibilities has culminated to what is known as protoscience. To Massimo Pigliucci and Maarted Boudry, “by definition, a protoscience does not possess all the features of a full-blown science” (Pigliucci & Boudry, 2013: 31). These yet-to-be sciences to them include areas like evolutionary psychology and memetics. Citing Cybersecurity as an example of protoscience, Eric N. Hatleback gives credence to Popper’s weighted possibilities as the yet-to-be theories of science. To him, “protoscience could develop the observation-gathering, experiment-designing, model-based capabilities cited by Popper and Kott as the prerequisite qualities for genuine science” (Hatlebach, 2017: 4). The propensity interpretation of quantum physics by Popper is thus important for it shows the continuity that exists between the micro and the macro worlds of science and it is an illustration that the actual world of science is just one of the many worlds

2.0 CONCLUSION

Macro and classical physics in its forms such as natural philosophy, the ancient Greek atomism, astronomy and mechanics was grounded on determinism. From sacrosanct causes and forces, macrophysics could account for motion in nature. The zenith of classical physics is epitomized by Newton’s mechanics that was the only explanatory models for two and a half centuries. With Max Planck’s attempt to quantize the radiation of heat and Einstein’s theories of special and general relativity, there was the crisis of precision and determinism, given that the quantum particles were not accessible using the classical methods of experimentation. The Copenhagen interpretation considers these quantum aspects like the waves exists in presupposition and they become particles only when the wavelength collapses during experiment. The wave thus does not have an objective existence and we cannot attain precise knowledge of it. Inspired by the Einstein-Rossen-Podosky thesis of realism, Popper rejects the Copenhagen interpretation for orientating physics into subjectivity and anti-realism. Considering Probability possibilities as propensities, Popper develops a realist interpretation, which is symmetric to the metaphysics of possibility. This does not only show the dialectics that exists between science and metaphysics but it also shows the rapprochement between the macro-physical and the microphysical worlds. This presents a double challenge: firstly, for antimetaphysical philosophy of science which is scientist, positivist and focuses on the elimination of meaphysics from scientific rationality, secondly, for antiscientific metaphysics, to rethink the relationship between Metaphysics and science and invest in finding how both disciplines nurture each other. Finally, it is hoped that policy makers in Philosphy and science uses our findings to revamp the conceptualisation and practice of interdisciplinarity, especially in the domains of science and metaphysics.

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