A CRITIQUE OF THE CONCEPT OF FORCE IN MODERN SCIENCE

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Abstract
Force, the paper contends has a material and immaterial dimensions bringing about the experience of motion, change of state and direction of an object. While Isaac Newton systematized the concept of force using mathematical postulates in his three laws of motion and the scientific method of observation and experimentation, it didn't erode the metaphysical underpinnings of the concept. The first, second and third laws of motion provides an ontological truth though with the fact of force being descriptive without stating what force is in itself. The paper interrogates the material and factual claims of force as being scientific from its ontological derivatives such as: motion, velocity, acceleration, mass, distance, change, gravitation, relativity, and space-time arguing that force does not strictly adhere to the scientific method of observation and experimentation. The paper further extrapolated the meaning of force and examines some metaphysical themes from the determination of the material status of the concept. The paper employed the method of criticism in tackling the problem that force has an ambivalent nature of the material and immaterial with one serving as the missing link of the other. Furthermore except perhaps for linguistic convenience, force doesn't really tell what it is in itself as a concept in modern science. Thus the findings of the paper reveal that the categories of the mind can delineate the immaterial from the material in a complementary manner thereby making force the object of both material (scientific) and immaterial (metaphysical) investigation with varied implications for man's social existential experience when pushed to one extreme.
Keywords: Force, Motion, Material, Immaterial, Metaphysics, Change, Shape, Object, Science

Introduction
Force possesses power or energy that propels an object into motion and at the same time, capable of changing its state and shape. Everything in the universe is energized by force and its fields whether chemical, mechanical, electromagnetic or mental aspect of reality. Little wonder, all the fundamental conceptions of force in modern science is categorized comprehensively under: gravitational, electromagnetic, strong and weak nuclear force and it explains every interaction and behaviour of particles of matter with Isaac Newton blazing the trail followed by Albert Einstein. Modern science developed with a complex range of philosophy, scholasticism, mysticism, Christian and secular humanism. Its rational thinking also developed through a long range of change and formation with the experiments of the enlightenments and breakthroughs in the sciences. Thus, according to Geisler and Bocchino (43), a thought system which is synonymous with "…a worldview is a philosophical system that attempts to explain how the facts of reality relate and fit together. In other words, a worldview shapes or colours the way we think and furnishes the interpretative condition for understanding and explaining the facts of our experience".

Accordingly, one very familiar but philosophically related issue with regards to force in Modern science is that it is metaphysically descriptive though held as factual and material. Force and by extension energy is held as neither created nor can be destroyed but it can be transformed from one state to another. What this implies is centered on how force propels objects or bodies into motion or how bodies interact through the processes of force. When force itself is questioned, it leads the questionnaire straightaway into the realm of metaphysics. For instance, how can the nature of the 'thing" that sets an object in motion be ontologically ascertained? How can it be grasped empirically following the scientific method of observation and experimentation? Is force of its own creation or is it from something outside of itself? Do all forces have cause and effect? How does the concept of force align with scientific hypotheses and theories? Is force outside of being or being outside of force?

Modern science adopts the method of observation and experimentation through hypotheses and theory formulation which upon reflection are metaphysically underpinned. Through this method, science has systematized and explained the concept of force. In the process, it has generated a lot of corollary concepts which are all inherently metaphysical such as: acceleration, velocity, motion, distance, mass, change, gravitation, relativity and space-time. Force though held as material and factual in Modern science is ontological upon reflection. What then is reality in scientific terms? Is it the case that theories in Modern science explain force as factual and empirical in the real sense of the word? Can atoms, electrons, bosons, mesons, leptons, quarks, hadrons, fermions and other micro-particles be given the same status of the materially real things? If what is real is measurable and testable following the scientific method, can Modern science be justified empirically? Consequently then, the problem identified is that: following the scientific method, force cannot be called factual or a material concept because it is outside the boundaries of empirical observation but an immaterial concept. Before the argument is advanced for this position, force in the three system of modern science or physics must be examined.

Force in Newtonian Physics

Newton first law of motion reads: Everybody continues in a state of rest or of uniform motion in a straight line unless compelled to do otherwise by an impressed force. If force is that which causes motion, how do we explain the case of a force without motion? And Newton himself said that there can be motion without force. To get around these two opposing facts, of motionless force and forceless motion, Newton stated his "third" law of motion: To every action there is an equal and opposite reaction. There are two forces then, one exerted by you, and one exerted on you. Thus: "Newton failed to make clear two important qualifications to both these laws. In the first law he should have said that there is no motion unless an unbalanced or net or excess force acts on the body, and in the third law he should have said that, if there is no acceleration, then to every action there is an equal and opposite reaction" (Pollard 64). Newton's laws of motion are contained in his *The Mathematical Principles of Natural Philosophy*, also known as *The Principia* from its Latin title. In the work, he introduced a tremendous innovation, which brought with it a considerable shock to many that a body moving in a straight line, with uniform speed, no matter how fast it is going, also has no force on it. Thus, force acts to change either a resting condition or a condition of uniform motion in a straight line.

The name Isaac Newton, seem to open up a new vista in modern science as it mediates between the ancient and the contemporary period as he is the founding practitioner of what we have come to understand as the methods of natural science. Scientists as well as Newton are not held to be preoccupied with matters not known empirically so that the interests of the scientist does not preclude things that are “transcendent” or “metaphysical”. In his *Philosophiae Naturalis Principia Mathematica,* Newton observes that:

All the difficulty of philosophy seem to consist in this-from the phenomena of motions to investigate the forces of nature, and then from these forces to demonstrate other phenomena. By the propositions mathematically demonstrated in the former books, we in the third derive from the celestial phenomena the forces of gravity with which bodies tend to the sun and the several planets (4).

Newtonian mechanics is the system of mechanics which relies on Newton’s laws of motion concerning the relations between forces acting and motions occurring. It is otherwise called classical mechanics and deals with the question of how:

An object moves when it is subjected to various forces, and also with the question of what forces act on an object which is not moving. The word “classical” indicates that we are not discussing phenomena on the atomic scale and we are not discussing situations in which an object moves with a velocity which is an appreciable fraction of the velocity of light, the description of atomic phenomena requires quantum mechanics, and the description of phenomena at very high velocities requires Einstein’s theory of Relativity…the laws of classical mechanics were stated by Sir Isaac Newton in 1687 (Cohen 111).

Thus, classical mechanics is useful in demonstrating how objects move and interact with other bodies in a world which contains automobiles, buildings, airplanes, bridges and ballistic missiles. Newtonian mechanics explains an incredible multitude of phenomena in the macro-world on the basis of a minimal, number of simple principles. Talking about the impact of Newtonian Mechanics, Anderson States that: “since the inception of civilization, there has been practical demand for “terrestrial mechanics’ in the form of Engineering and for ‘celestial mechanics’: due to its time keeping. Indeed Newton’s laws of mechanics alongside Newton’s universal law of gravitation unified the previously separated subjects of terrestrial and celestial mechanics. This Newtonian paradigm also provided the practical means of further understanding and predicting a very wide range of phenomena” (20).

Newtonian mechanics therefore describes the motion of bodies under the influence of a system of forces. It provides extremely accurate results when studying large objects that are not extremely massive and speeds not approaching the speed of light.

It further uses common sense notions of how matter and forces exist and interact. It assumes that matter and energy have definite, knowable attributes such as location in space and speed. Thus, Koyre, asserts that:

The great success of Isaac Newton in using mathematical reasoning and observation to discover the law of universal gravitation and in employing experiments to determine the various colors in a ray of sunlight convinced many that his method was capable of solving virtually all problems. Alexander Pope expressed a widely held feeling with his famous couplet: Nature and Nature's laws lay hid in night: God said let Newton be! And all was light (136).

The overwhelming success of Newtonian mechanics or physics made it practically inevitable that its particular features became thought of as essential for the building of science, of any kind of science as such and that all the new sciences that emerged in the eighteenth century sciences of man and society tried to conform to the Newtonian pattern of empirico-deductive knowledge. The paper now turns to examine force in relativistic physics with Einstein as its theorizer.

Force in Relativistic Physics

The inadequacies of Newtonian mechanics to describe and explain the behavior of objects at the micro level of reality moving close to the speed of light in random motion necessitated the science of relativity. Relativity physics, theory or Relativistic mechanics refers to mechanics that is in tandem with the special relativity (SR) and general relativity (GR) which are all the discoveries of Albert Einstein. In relativistic mechanics, forces act on particles or is exerted by particles. Thus, what appears to be "moving" and what is "at rest" as we know it in Newtonian Mechanics, depends on the relative motion of "observers" who measure in frames of reference i.e. the point where they are standing. Russell asserts that: "everything in the heavens is moving relatively to everything else. The earth is going round the sun, the sun is moving very much faster than an express train, towards a point in the constellation. Hercules, the "fixed" stars are scurrying hither thither. In special relativity, motion is relative and the laws of physics are the same for all observers irrespective of their inertial reference frames. Relativistic mechanics also modify notions of space and time into space-time and forces one to reconsider the concepts of mass, momentum and energy all of which are important constructs in Newtonian mechanics. Li Wen-Xiu puts all of these into a definite perspective thus:

There is no doubt that the physical universe is the only object of study of physics. The basic view of the world, underlying all physical theories and justified by history of physics, is the doctrine that the world is made up of objects whose existence is independent of human consciousness. The objectivity, reality, and uniqueness of the universe are therefore the initial premises of natural science. Based on this view, the phenomena of nature, which ultimately depend only upon interaction between matter and relative motion thereof, can simultaneously be described by means of a single coordinate system, i.e. nothing in the universe can be changed by the employment of a coordinate system (21).

Relativistic mechanics therefore, is different from non-relativistic mechanics i.e. Newtonian mechanics because of the premium given to speed, especially the one close to that of light. Pondering on objects moving close to this speed (299, 792, 458 ms-1) leads to some of the most amazing physical idea ever. Force in quantum physics is next.

Force in Quantum Physics

Before we can delineate the idea of force in quantum physics or mechanics, it will be pertinent we elucidate what quantum mechanics represents. Physical objects seem to have the characteristics of both particles and waves. Newtonian mechanics describes the particle properties of objects, while quantum physics describes the wave properties of objects. Zukav explains that:

A "quantum" is a quantity of something, a specific amount: "Mechanics" is the study of motion. Therefore, "quantum mechanics" is the study of the motion of quantities. Quantum theory says that nature comes in bits and pieces (quanta), and quantum mechanics is the study of this phenomenon. Quantum mechanics does not replace Newtonian physics, it includes it. The physics of Newton remains valid within its limits…what we actually discover is that the way that we have been looking at nature is no longer comprehensive enough to explain all that we can observe (19).

Quantum mechanics deals with the motion and behavior of sub-atomic particles leading to randomness because of their wave like behavior. One of such interpretation is the uncertainty principle developed by Werner Heisenberg "which held that atomic particles can never be completely defined, for the more their motion is pinned down, the more uncertain their position becomes (Christian 515).

The birth of quantum theory in 1900 and special relativity theory in 1905 were major advances that profoundly changed our picture of the physical world. Albert Einstein's contribution to quantum theory was his concept of light as "light quanta". There are a lot of other theories in quantum mechanics all geared towards giving us a holistic and comprehensive understanding of the mechanics of sub-atomic particles. This is why quantum mechanics seem very vast and difficult to grasp especially when we approach it from its abstract mathematics. But it is sufficient at the level of this paper to state that:

Quantum mechanics is commonly defined as the system of mechanics that was developed from quantum theory to explain the properties of atoms and molecules. A number of developments led to the establishment of a quantum mechanics. First Planck's discovery immediately overturned the universally accepted notion in classical physics that energy is a continuous variable. Instead, it is 'granular' and 'discrete'. The concept was taken forward crucially by Einstein, who explained details in the photoelectric effect by proposing that radiation itself is "quantized" (Steward 1).

The concept of force therefore is to be found in the characteristics of particles and what energizes them. Since these particles are wave-like in nature, they must be propagated by electromagnetic forces. It could either be kinetic energy or potential energy. These particles like the electron, moves in empty space and is believed to have its own force fields which are a metaphysical construct such that "experimental arrangements compel electrons to take certain values as position and momentum" (Mbat and Archibong 158). Basically then, there are no force vectors *parse* in quantum mechanics only expressions of energy. The paper shall now attempt to situate the concept of force as being better understood as an immaterial reality rather than a material one ontologically speaking.

An Ontological Inquiry into the Status of Material Reality of Force in Science

When the atomists, Democritus, Leucippus and Lucretius came up with the idea of atom as the smallest indivisible particle of matter, some kind of reality akin to Spinoza's *monads*, little was it conceived that it will only take a matter of time for scientists to discover other hundreds of micro particles that are not perceptible to the direct senses moving with a speed equal to that of light occasioned by fields of force. This was known because scientists have evolved a method that has made science very fascinating and reliable with regards to knowledge attainment of nature and its processes. This is perhaps what Stephen Jay Gould had in mind when he asserts that "in science, "fact" can only mean "confirmed to such a degree that it could be perverse to withhold provisional assent" (Gould 253).

With the synthesis of rationality and experimentation, the basic constituents of matter began to be identified and the unfolding process lead to its justification. Thus the context of justification is:

Concerned with the rational features of scientific practice, and particularly with the issue of how theories are justified, or supported by the evidence. This is open to investigation by philosophers because it covers what is rational about science….. They hypothetico-deductive account is a very well-known and much-discussed view of how science works. It meshes with the Romantic view of discovery by insisting that science works by coming up with hypotheses in some creative way and then justifies these hypotheses by testing their experimental consequences (French 12-13).

What constitutes the structure of material reality has been the utmost concern of thinkers about nature. Beginning from the Ionians down through Aristotle, substance seems separated from its accidents just as atoms seem separated from its particles. Durbin (78) sets the issue at hand in perspective when he opined that "an approach to the intelligibility of the world can be mechanistic, realistic and positivistic. But what about the world itself that is being approached? The most fundamental aspect of this world, as an object of science and the philosophy of science, is matter. What is it? What are its components? How does it act, if at all? How is it structured, interrelated, locked together to form a world that can, because of it, be called "material"? It was Ernest Rutherford in the modern era that proved that the atom is not the smallest unit of matter. Christian opines in line with this point that:

The critical distinction between what is real and what is only experiential has been entirely obliterated in physical thinking, making it virtually impossible to honor the principle that demands that we think about objects in their true contexts and not commit the error of interpreting them in terms of false functions. I once asked a physicist to tell me how physicists deal with the subject – object problem. His reply: "they just ignore it". As they must – as physicists (506-507).

The material dimension of reality often cuts across the mental and emotional processes of human beings in making contact with the external world. We could also call it the psychological underpinning of human existential reality. But there is a problem if we try to subject thoughts to measurement. How can we measure thought processes? This task is arduous because "it would be foolish, for example, to try to explain the concept of atom in physics solely in terms of what goes on in our (conscious and unconscious) minds without considering the actual material things that are described by this concept" (Hutten 49-50). The primacy of a psychological explanation in science cannot be overlooked howsoever. Willer (31) sees science as "all thinking which combines rational, empirical and abstractive thought. Neither catalogues of empirical facts nor rational systems such as mathematics is scientific thinking by themselves. No system of knowledge is scientific unless it connects the observational and theoretical levels". Though Popper refused to be called a positivist, he nevertheless contributed to the discourse of demarcation in science a course pursued by the logical positivists. He avers that:

My main reason for rejecting inductive logics is precisely that it does not provide a suitable distinguishing mark of the empirical, non-metaphysical, character of a theoretical system; or in other words, that it does not provide a suitable criterion of demarcation. The problem of finding a criterion which will enable us to distinguish between the empirical sciences on the one hands, and mathematics and logic as well as 'metaphysical systems on the other, I call the problem of demarcation (11).

This demarcation project seems to be better carried out using the scientific method. With this method therefore, physical concepts can be separated from non-physical ones just like empirical realities from non-empirical ones. Archibong and Nkanta (21) summarizes the tenets of positivism to include: "the unity of science, the rejection of metaphysics, the language of science and the principle of verifiability. Science amidst its diversity in terms of subject matter employs the same methodology. The elimination of metaphysics, on the other hand, presupposes that experience and observation authenticate the scientific attitude". Since empirical basic statements must be factual, Aigbodioh defines scientific facts as constituting:

Sense-data (givens) or "empirical truths" about the world. They are the raw and primitive ingredients from which scientific hypotheses, laws and theories are formulated and extracted out of experience…Newton's theory or laws about celestial mechanics (that is about the forces or dynamics of physical bodies) are said by Newton himself to be wrested…from experience by induction" and logically derived from the truth of certain observation statements….Which report facts of immediate experience (35).

Since we have been able to have a clear demarcation of empirical basic statements and non-empirical ones and have noted that empirical facts are to be observed or perceived with any of our five senses of touch, sight, hearing, smell and taste, where can we then place the concept of force? Is force a concept that can be perceived with any of this senses? Collingswood (19) asserts that "that which was essentially not experienced by the senses, that which was unchangeable and in some way spiritual, became known to the Greeks as the "metaphysical".

Force therefore following the Aristotelian distinction of substance and accident, essence and existence, act and potency, change and permanence must be so understood. Force has a material and immaterial, scientific and metaphysical aspects in which it can be understood and explained. To know the concept of force whether as a material or immaterial reality swings between the systems of empiricism and rationalism of which Kant sought to reconcile through synthetic a priori and it is engendered by that fact that it points to being or non-being. Deductively then, being can be investigated as well as non-being so that the word nothingness can be extrapolated from something even in science. Poldony (9) asserts that "…the layout of our galaxy and the universe itself, constitute a cosmic whole that is built on a foundation of the void or vacuum". That force can be delineated as one of the perennial problems in metaphysics would not be out of place whether it is understood as a material reality or in the laboratory of the mind. Like thought experiments, "we recognize them when we see them: they are visualizable; they involve mental manipulations; they are not the mere consequence of a theory-based calculation; they are often (but not always) impossible to implement as real experiments either because we lack the relevant technology or because they are simply impossible in principle" (Brown 1). The paper now examines the notion of motion and change as a consequence of the metaphysical nature of force.

Motion and Change

Motion and change are fundamentally the outcome of force. Where ever there is motion, force must be behind it. This is why in modern science, motion is a change in position of an object over time. But the change to be examined here is as contrasted with permanence in metaphysics. The universe contains things that appeared to change; yet these very same things also possessed a certain endurance and permanence. While Heraclius is the apostle of change, Parmenides is the apostle of permanence. However, it was Zeno of Elea, Parmenides student who devised some well-known logical paradoxes that supposedly demonstrated the contradiction of motion. Pagels notes that:

Not only does quantum theory deny the standard idea of objectivity, but it has also destroyed the deterministic worldview. According to quantum theory, some events such as electrons jumping around atoms occur at random. There just isn't any physical law that will ever tell us when an electron is going to jump; the best we can do is to give the probability of a jump. The smallest wheels of the great clockwork, the atoms, do not obey deterministic laws (47).

Granted that events in the universe do not move close to the speed of light to necessitate randomness on a wider atomic scale, but that does not negate the fact that all objects in the universe are in constant motion. Even when a person is sitting still in a chair, the body is moving thousands of kilometers per second. The earth is spinning on its axis, carrying us with it. The planets orbits the sun, which is a star orbiting the center of the Milky Way Galaxy. There are normal everyday motions such as a rolling ball or a moving vehicle in the midst of other motion. The concept of force is also responsible for several of the familiar and unfamiliar features seen in the universe.

Evaluation

The Western scientific tradition has no doubt made meaningful contributions to humanity in diverse areas. And the union between science and technology has also seen to ground breaking material feats that has added value to human life and existence. The gains of science and by extension technology are far reaching and have made the world and its culture more sophisticated. Economically, science and technology have led to the invention, creation and innovation of products that humans necessarily need. As these needs are met, so are the economic fortunes of the creators of the product. Today, countries are classified as developed, underdeveloped or developing because of economic indices and countries with indigenous science and technology are predominantly developed countries. This is why the continuous development of science and technology is part of the policy framework of most developed or advanced countries.

But just as we can eulogies the gains of science, we can also speak though sadly, about its losses. Science has removed the supernatural and metaphysical completely from its scheme of things even though it still gets around it somehow. Its chief concern about that which can be demonstrated empirically has left the enterprise with more philosophical problems that it can deal with of which force is one. Drawing the boundary that any claim that does not have a physical referent of measurement is not considered real raises more questions about the concept of observation and experimentation as scientific methods. For instance, sound doesn’t exist in nature but only sound waves. The brain creates and interprets what we call sound. This is how bizarre and fuzzy observation supposedly “facts” derived from the scientific method appears. Yet the scientific method emphasized the need to conduct tests and to make detailed observations of the results before having confidence in any claim.

This new realization that reality and by extension truth is the observable, testable and demonstrable has led to the belief in atheism on one hand, and disbelief in everything supernatural on the other as extrapolated in the concept of force. Following the scientific method, we can further deduce that the mind is a bye product of the brain so that dreams are just the workings of the brain when the body is asleep, death is annihilation, the universe has no creator, no beginning *per se* as it has always existed, morality is subjective and relative and there is no absolute truth, empathy is part of the human makeup of cells and hormonal activities and so on and so forth. These are all fundamental basic beliefs occasioned by the scientific attitude and they determine its adherent behaviours.

The movement that is a consequence of modern science is secular humanism. It revolves around the ingenuity of man, and what he makes of his existence in this universe without recourse to any reality external to himself. It is a principle or system of belief which holds that life in this material universe is all there is and so it behooves on man to maximize this one life to the fullest. Man becomes the product of natural processes hence any talk about the non-material, supernatural, Supreme Being and creator, Supreme force other than the four fundamental forces, or sacred texts as a guide to truth and knowledge is scorned at as man is held as the only reality there is and he should be able to think for himself and collectively with others in other to face or resolve his existential problems through reason, empirical research, compassion and empathy.

This kind of thinking actually has some plausibility the paper concedes in all fairness. It simply states that, since supernatural or non-material claims are outside the stretch of empirical investigation, then they are not real. An adherent of science will ask by which other way non-empirical reality can be apprehended outside the senses especially when every aspect of man's experience has been reduced to natural processes? But the truth is that, if there is actually no Supreme Being or force who is the creator and sustainer of the universe and man, if all the forces there are in the universe came as a result of blind chance, then it will be foolish or a waste of time to talk about what is moral, right or wrong, after life and eternal judgment. The reason being that there will be no purpose for living hence everything becomes permissible, the case of might makes right and justice becomes the interest of the stronger. It is often argued however that there are two forces that man had to deal with in his evolved consciousness and they are nature and gods: One could say that humanism was born the moment when man started to reflect on his place in the world and on his possibilities of sovereign action in relation to nature and the gods. A condition of this self-reflection was that the pressure exerted on him by the other two members of our triad became to some extent alleviated.

Conclusion

In closing, it is pertinent to question concepts and how they play out in the overall scheme of things in man's social existential reality. In so doing, it exposes the deep philosophical underpinnings of such a concept and shows how it influences our commitment and cherished beliefs. Force therefore in modern science, despite its scientific sophistication still remains problematic ontologically as it has been shown.

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