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Fundamental Principles

The foundations of physics include a number of unanalysable concepts, axiomatic premises and ultimate principles which are essentially metaphysical. These rational elements form a framework of assumptions which serves as an indispensable ordering and linking pattern for the unprocessed and disconnected pieces of information acquired by studying nature. Newton's mechanics, the core of classical physics, is based on a set of partly explicit, partly implied and partly hidden assumptions, and so is Einstein's relativity theory. The presence of metaphysical elements as such in the foundations of physics is not a problem. Philosophical ingredients enter into the composition of fundamental ideas practically in all branches of science. The predicament lies in the fact that Newton's and Einstein's assumptions differ. Some scholars assert that Einstein has provided the principles for a new and completely non-Newtonian mechanics. Irrespective of whether this is the case or not, we are faced with serious discrepancies and have to decide which of the two alternatives is valid.

Of course, the "canons" or fundamental principles themselves are, or ought to be, derived from nature. However, such rational elements are not immediately given and are not obtained in the same way as the results of direct observation, measurement and experiment. They have to be abstracted from an extensive range of physical phenomena which have been subjected to a process of interpretation, generalisation and other refinement. Furthermore, abstraction requires a substantial purely mental contribution. An active participation of the mind is necessary to formulate the conceptual content of a principle, and reason as well as imagination influence the shape of the end product. Consequently, fundamental principles are epistemologically quite different from the initial empirical building stones of physics. Their validity is more open to doubt. They contain philosophical elements which cannot be proved or verified in the same way as the initial physical facts, and they can, therefore, only be considered as plausible assumptions or presuppositions which may be substantially right, but may also be in need of improvement or amendment. However, without a set of such assumptions the pursuit of physics would not be possible.

There is no generally accepted way of identifying, differentiating and grouping assumptions, even those which have been explicitly stated, discussed and accepted by philosophers and physicists. The situation is aggravated by the fact that some assumptions are considered as implied by others, some have never been sufficiently clearly elaborated, some are unstated but commonly understood and some may still be completely hidden. We will distinguish four fundamental principles of physics, or "ensembles" of fundamental propositions, under the following titles: (a) reality, (b) uniformity, (c) causality, and (d) dimensionality.

The first and most elementary metaphysical principle of Newtonian physics is that there exists an external reality which is called the physical world or nature. Although we derive our knowledge of it through the senses, the physical world is nevertheless independent of any human mind. This assumption is supported by the far-reaching coincidence in the description of sense data by any given number of observers. The fact that we can arrive at a consensus as to what we individually perceive so easily and naturally compels us to believe in the existence of an objective world. The purpose of physics is to study and describe this objective world profoundly and systematically. The belief in the external reality implies that this reality is comprehensible and describable, and that it can be re-created by the human mind. The aggregate weight of agreement among physicists completely dwarfs any disagreement. Thus, the justification of the realist point of view is embodied not only in the consensus achieved by physicists in the process of studying nature, but also in the highly sophisticated and yet uniform body of knowledge resulting from their efforts, and particularly in its usefulness and reliability. The principle of external reality is, of course, closely associated with one of the central problems of philosophy. The Newtonian viewpoint in the ideological spectrum is that of a moderate realist who accepts the totality of external being and sees himself as a part of it, and who subordinates epistemological considerations to the ontology which is uncovered primarily through the detailed study of the physical world, but who does not wish to become embroiled in complex and purely theoretical questions of philosophy.

In the Einsteinian metaphysics the first elementary principle is already and considerably modified. The existence of the physical world is admitted, but at the same time a shadow is cast on its reality and comprehensibility. Einstein's view is as follows: *The belief in an external world independent of the perceiving subject is the basis of all natural science. Since, however, sense perception gives information of this external world or of "physical reality" indirectly, we can only grasp the latter by speculative means.*

In the Einsteinian scheme of things the comparative importance of the two factors in the cognitive process, object and subject, has changed. The primacy no longer resides in the physical world, but in the mind of the person who studies it. The emphasis has shifted from cosmocentrism to anthropocentrism. Reality is now studied and grasped primarily not by empirical methods and induction, but by intuition and deduction: *The supreme task of the physicist is to search for those universal laws from which a picture of the world can be obtained by pure deduction. There is no logical path leading to these laws. They can only be reached by intuition* (Einstein). The physical world is no longer re-created in correspondence with external objects. It is constructed by speculative thought processes guided by criteria which are also inherent in the mind. The element of subjectivity becomes clearly more prominent than that of objectivity. Einstein follows the philosophical tradition of Hume. His structure of being is subsidiary to his theory of knowledge.

However, the change in emphasis from objectivism to subjectivism is not the only modification applied by Einstein to Newton's moderate realism. A further, and more specific, variation is injected by Einstein into his epistemological anthropocentrism. This is the principle of mathematical pre-eminence. This principle not only encompasses the preferential position of mathematical language in the description of physical processes, but, in effect, becomes a cornerstone of Einstein's whole epistemology. In his opinion it is self-evident that primary consideration in physics must be given to the mathematical formalism and it is not essential to establish its physical meaning. But that is not all. According to Einstein physics is brought into being by imagination and *the creative principle resides in mathematics.* Einstein asserts that *our experience hitherto justifies us in believing that nature is the realisation of the simplest conceivable mathematical ideas*, and that *we can discover by means of purely mathematical constructions the concepts and the laws connecting them with each other, which furnish the key to the understanding of natural phenomena.* Einstein does not reject experience as a factor of some importance in the process of knowing, but it is accorded a subordinate role. The usefulness of experience lies mainly in its ability to assess or establish *the physical utility of a mathematical construction.* As part of this procedure it is, for instance, quite legitimate to posit purely hypothetical situations, including thought experiments, to introduce or validate parts of a mathematical construction which are empirically missing.

Mathematical pre-eminence is not a Newtonian principle, despite the fact that it was Newton who developed mathematical methods in physics and employed them rigorously for the first time. On the contrary, it would be more correct to say that Newtonian physics tacitly assumed, but never formally pronounced because of its self-evidence, the principle of immediate apprehension of reality and what one could call the logico-linguistic pre-eminence in the study and description of the physical world. At the same time it considered mathematical "language" as an extension of the verbal and conceptual description, and always in need of semantic correlation and elucidation. The principle of immediate apprehension and logico-linguistic pre-eminence has never been displaced or abolished. It is still firmly accepted that the existentially and epistemologically significant range of physical processes is apprehended without the use of symbolic or instrumental methods and described by verbal conceptual language, i.e. by means of communication ordinarily used between people, although with terms more precisely defined than in common language. In order to achieve quantitative exactitude in measurements and predictions it is customary to express physical phenomena in mathematical terms and to employ mathematical calculations. It is, of course, also legitimate to extend mathematical methods of analysis into the realm of phenomena which lies outside the range of immediate apprehension. However, it is not justified to attach, for instance, ontological significance to microprocesses whose physical meaning has not been clarified or which are specifically declared to have no physical meaning. Mathematics in physics is strictly a method, not a theory of being or knowledge. It is a procedure, or an instrument, used by the researcher to extend the scope of his investigations, to achieve a deeper penetration of his field of study, and to acquire a better knowledge of it. A researcher who restricts his freedom by assuming that he must find a reflection or analogy of mathematical relationships in nature, or tries to impose such relationships on the results of his research, is acting contrary to the letter and spirit of true science.

Einstein pre-empts the question of truth in science in favour of one fairly restricted option, and no compelling reasons have ever been given why the search for utility, pragmatism, validity or truth in science must be subordinated to mathematics or sanctioned by mathematicians. Einstein's principle has no empirical basis at all. Among all presuppositions of physics it is the one which has not been abstracted from any natural phenomena and belongs to the realm of pure metaphysics. No sound metaphysical arguments, however, have ever been advanced in favour of it. Einstein himself has not attempted to justify mathematical pre-eminence as a fundamental principle, with the exception of a few cryptic references to Leibniz and his "pre-established harmony". Its acceptance by relativists rests solely on the acceptance of the authority of Einstein.

The second fundamental principle, or group of principles, deals with uniformity, the universal or most general characteristics of reality. Newtonian physics assumes one universe embracing all physical phenomena and this assumption has several important implications. The first implication is the hierarchical subordination of all physical entities to the oneness, uniqueness and wholeness of the universe. In other words, if the universe is a whole, an ultimate totality, and that is exactly what the principle of uniformity is all about, then anything else which has a physical existence is part of it and must in some way or other, directly or indirectly, fit into the whole and be related to it and cannot have an independent status in an absolute sense. No part of the universe can also be functionally completely separate from other parts. If the Newtonian universe is accepted, the examination of any individual entity in the universe must take into account not only its properties and its immediate environment, but also its hierarchical status and function within the universe as a whole.

Another implication of the principle of uniformity is the universal validity of any generalised statements of behaviour established in any part of the universe. This means that a physical law established in the terrestrial domain is assumed to apply in the whole universe, that extrapolation on this basis is a valid method of investigating and explaining extraterrestrial phenomena, and that propositions contrary to established laws should not be postulated without very good reasons. It also means that observations or measurements made in any part of the universe of a specific physical quantity or situation will be the same in any other part of the universe.

It is very important to realise that Einstein mostly tacitly, but nevertheless quite definitely, denies the oneness and wholeness of the universe in the

Newtonian sense. He assumes an indeterminate number of ultimate entities which are physically equivalent and are described as inertial reference points or reference frames based on these points. Einstein's inertial reference frames have an independent existence in absolute terms. They are independent of each other and are neither theoretically nor practically integrated in, or related to, a higher, all-embracing and universal, hierarchical entity. The notion of the one and whole universe is deprived of any meaning in special relativity.

The denial of the principle of uniformity by Einstein results also in the invalidation of the universal applicability of physical laws. In special relativity physical laws lose their absolute significance and become dependent on observers in relative motion associated with inertial reference frames. However, two specific additional assumptions, known as the relativity postulate and constancy of light postulate, are exempt from observer-dependence and are elevated by Einstein's fiat to universal and absolute laws although there is no universe. Furthermore, all Einsteinian assumptions are made subject to a curious limitation. They are valid only in respect to reference frames moving inertially relative to each other. If there is no relative motion, and if the motion is not uniform and rectilinear, the Einsteinian assumptions are inoperative and Newtonian conditions apply. One is justified in asking: can nature really be so arbitrary, ambivalent and grotesque?

Einstein presupposes what should be properly called a "multi-verse", a universe with a split personality, and split in as many ways as one cares to imagine. It is a philosophical as well as physical monstrosity. However, it is possible to offer some explanation on the basis of Einstein's principle of mathematical pre-eminence. If one is looking in physics for a reflection of mathematical relationships, then, of course, there cannot be any universe. There is nothing corresponding to the universe in geometry or any other branch of mathematics. The "totality of all geometrical points" is a meaningless phrase. Mathematics has no relevance to things which are unique and hierarchical, but a multitude of unstructured entities of equal standing, similar to integers or geometrical points, is certainly something of relevance to mathematics. However, Einstein must have felt that the mathematical fragmentation of the universe affected the credibility of his theory, and he was searching for a unifying idea. He found it in what he calls invariance. By invariance he means the uniformity of mathematical expression of the laws of nature. This expression is, or must be, the same in all inertial reference frames. Einstein is again concerned only with the mathematical form of laws, not with their physical content and meaning. The Einsteinian invariance is nothing more than an immaterial embellishment of his theory. It is metaphysically empty and has no significance in physics.

A third fundamental principle of Newtonian physics is the principle of causality. Causal relationships have been the subject of philosophical investigations for a long time, and continue to receive attention by contemporary philosophers and scientists. In the realm of physics the concepts of cause and effect are used in a narrower sense than in other areas of human inquiry. Physics is not concerned with existential causes. This means that it is accepted that there is a certain quantity, range or category of phenomena which have the capacity to act as physical causes, but are themselves not affected by any physical events. This category is assumed to be endowed with absolute existential stability. It is indestructible and imperturbable, and physics does not ask where this indestructibility and imperturbability comes from. It is taken for granted that there are unanalysable entities which are just as much part of physics as they are of metaphysics.

Apart from the unanalysable and physically undisturbable prime concepts, such as matter, all other physical phenomena are integrated in cause and effect sequences which form the basis for the reliability and predictability of physical events. Every specific event has a specific cause. The relationship between cause and effect is not one of accidental succession, but of compulsory origination. The cause generates the effect. Both factors of this pair have, or are presumed to have, an exact physical meaning. Causality is a very important presupposition of Newtonian physics and any deviation from it must have serious consequences not only for physics, but for all branches of science. It is a metaphysical assumption, but if it does not work, science is useless.

Some philosophers, particularly Hume, have argued that a cause does not generate an effect and that the cause and effect relationship exists only in our imagination. In actual fact, there are no causal connections, but only successions of events. The similarity of some event sequences creates the notion that one event in the sequence is caused by the other. This successionist theory has never had any impact on physics, but it is known that Einstein was an admirer of Hume's philosophy. It is no coincidence, therefore, to find that Einstein's special theory incorporates proposals modifying the metaphysical foundations of physics and that some of them are in direct conflict with the principle of causality. Although it is not the crude successionist view of Hume which is ostensibly used by Einstein, it is nevertheless a theoretical approach which is compatible with a successionist view and which represents a deviation from the strict cause and effect requirements of Newtonian physics. As in the case of the denial of the uniqueness of the universe Einstein derives his modification of causality from his epistemology, i.e. from his principle of mathematical pre-eminence. Einsteinianists are indignant when it is imputed that they have repudiated causality. They are fond to point out Einstein's well-known disagreement with the abandonment of strict cause and effect relationships in quantum mechanics. However, no protestations can hide the fact that relativity is equating mathematics with dynamics and endowing it with ontological reality, i.e. with attributes of the external world. It is within mathematics where a cause and effect relationship operates, and not in the external reality which the physicist, erroneously in Einstein's view, considers to be the primary object of his research. In accordance with this assumption the results of mathematical calculations become equivalent to effects in terms of a causal sequence. If a formula leads to a certain mathematical "effect", the latter has to be considered also as physically possible and real. It is incumbent on the physicist to look for the mathematically derived "effect" in nature. As a result of Einstein's epistemological assumptions we are compelled to accept such weird and antiphysical phenomena as length contraction and time dilation.

A fourth fundamental principle of physics deals with the dimensionality of nature. Certain ontological divisions can be distinguished in the universe which are very basic and unanalysable. They are recognised and acknowledged by the mind intuitively. They form an elementary pattern and background for every physical description. They are necessary for the comprehension of the physical world. They serve as prime causes in terms of cause and effect relationships. And they affect vitally the structure and action of all physical entities, but remain themselves unaffected. These ontological divisions require to be explicitly stated in order that physics can proceed, but like other fundamental assumptions they are essentially metaphysical. Their intimate connection with physics and their indispensability tend to obscure the fact that, in themselves, they are abstractions which are not directly observed in nature. The divisions are referred to as physical dimensions, and experience shows that three fundamental dimensions are necessary and sufficient to describe all phenomena of Newtonian mechanics. The dimensions are extension, duration and matter, or space, time and mass. All other dimensional concepts, such as velocity, acceleration, force, energy, power, etc. can be derived from the fundamental dimensions.

It is said that the choice of the fundamental dimensions is arbitrary. Others could be chosen, such as force, energy and power. The dimension of space would then be derived by dividing power by force. Other dimensional derivatives would be represented by combinations of the three dimensions selected as fundamental. However, this approach overlooks important reasons why space, time and mass specifically are considered fundamental. They are simpler, and pragmatically more convenient, than other combinations. They are directly measurable, while other combinations, as a rule, require the determination of space, time and mass first. They are intuitively apprehensible and are associated with conceptually and qualitatively well-defined and separable divisions of profound physical and metaphysical significance, while force, energy and power, for instance, cannot be readily apprehended or differentiated, except with the aid of reasoning processes and the use of space, time and mass, and although physically distinct, their individual perceptibility is not prominent and has no metaphysical implications worth mentioning. It is, therefore, not surprising that physicists and physics textbooks accept unhesitatingly, without qualification, and without searching for alternatives, that space, time and mass are the fundamental dimensions of the physical world.

The original principle of dimensionality had to be extended, without affecting the fundamentality of space, mass and time, by the introduction of supplementary concepts which could not be expressed in terms of the three Newtonian dimensions alone. At this stage it is not possible to say whether this inability is due to lack of knowledge or that additional fundamental assumptions are involved. The Newtonian assumptions were adequate for mechanics, but in electricity, for instance, there is some quality which has so far defied description in terms of space, time and mass alone. However, although it may be said that supplementary assumptions have been necessary, the original principle of dimensionality has never been challenged, except by Einstein.

Newtonian space is empty, inert and Euclidean. Newton also speaks of the absoluteness of space, and by this he means firstly that space is absolutely rigid and imperturbable, and secondly that if a physical body is placed in a specific point in space and remains there, it may be considered absolutely at rest. This implies the possibility of determining or identifying unequivocally every point in space in relation to some universal, fixed and observable feature or absolute reference frame. Newton points out that this feature could be the system of the fixed stars, but does not pursue this matter further. One of his arguments in support of absolute rest is based on the consideration of circular motion, such as the behaviour of water in a rotating bucket. Newton advances various reasons why the fixed stars, in relation to the bucket, must be absolutely at rest. However, no answer is provided in relation to rectilinear motion, and how a particular point in space can be exactly designated. This inability has been exploited by Einstein. He assumes the opposite, namely that a point in space cannot be absolutely determined, and this assumption serves as a departing point for the special theory. Einstein otherwise accepts Newtonian space. Some of his postulated effects, such as length contraction, are, of course, incompatible with Newtonian space if they are interpreted as real effects. It must also be noted that in the general theory Einstein completely rejects the Newtonian concept of space.

The essential core of Newton's concept of time is the constant, uniform and imperturbable time-flow, a well-founded and generally accepted assumption indispensable to physics. The rejection of this assumption is regarded as Einstein's greatest "achievement". Einstein formally endorses only the measurement of time, not time as such, and he postulates a synchronical time measurement sequence only within a system based on an inertial reference frame. Another system, also based on an inertial reference frame and in relative motion to the first, has, according to Einstein, a different time measurement sequence. There is no universal time.

The concept of mass was introduced and elaborated by Newton. He arrived at it by studying inertia and gravitation, and by reducing the motion of physical bodies to exact mathematical formulas. He found that in addition to space and time a third basic unit was needed to explain the phenomena of mechanics. Newton assumed that mass is the measure of the quantity of matter contained by a physical body. However, there is no direct way of measuring a quantity of matter. Mass is determined by its gravitational attraction or by its resistance to acceleration. The concept of mass has been complemented by the principle of the preservation of mass, and these assumptions have contributed substantially to the success of physics and chemistry in the 19th century. However, it became apparent that the concept of mass requires an adjustment. It was discovered that light, previously assumed to be without mass, had properties indicating the contrary, that particles in motion displayed a mass increase, and that in processes in which atomic nuclei divide mass is not preserved. Newton's concept of mass had to be more adequately delineated and re-defined in relation to the concept of energy. A distinction became necessary between rest mass and kinetic mass. During this re-assessment it transpired that a formula is operative in kinetic mass processes based on what was previously known as the Lorentz factor. The same formula was introduced by Einstein in the special theory and used to support very sweeping propositions affecting the foundations of physics. The association of the formula with the observed mass increase has led, more than anything else, to the widely accepted view that the special theory has been confirmed by experience. To what extent this view can be sustained will be discussed in a subsequent chapter of this work.

Einstein's disagreements with Newton originate in the foundations of physics. Einstein has proposed new presuppositions which are different from, or contrary to, the Newtonian presuppositions. He uses them whenever they serve his purpose, but without really abandoning Newtonian assumptions which are inconsistent with his own. This ambiguity is a permanent source of confusion and misunderstanding in any discourse on relativity or argument with relativists. The depth of the metaphysical estrangement can be gauged by McCrea's attitude to Dingle's criticism, which has already been mentioned. *Dingle's assertion is obviously and demonstrably wrong*, declares McCrea. And he gives the reason: Dingle *deals with objects to which the theory* of relativity *explicitly denies a meaning*. In other words, you are permitted to discuss and criticise relativity, but only if you accept the relativistic presuppositions and remain within the conceptual framework of the theory. If your position is not in harmony with relativity, you must expect to be told that you are *obviously and demonstrably wrong* because you use concepts which have no meaning or because you do not *adhere to the standard concept* (McCrea). Whenever a relativist refers to a "standard concept", it is very unlikely that the concept has an agreed meaning, or even a confluent meaning, for all participants in a discussion. This is due not only to the two faces of relativity, the Einsteinian and the Newtonian, but also to the inherent fluctuations of meaning in some Einsteinian concepts and to the obscurity of some of his formulations. In strictly logical and metaphysical terms the gap between Newtonian canons and Einsteinian propositions is unbridgeable, and a contest between them cannot result in a compromise. If one alternative is accepted, the other must be rejected. However, nothing will be achieved by rejecting Newton because Einstein does not offer a complete, clear and consistent set of presuppositions. Einsteinianism is not a viable alternative to Newtonian physics.