THE CONTINUITY OF SCIENTIFIC REVOLUTION :

1. The logical structure of pre-1500 scientific theories was only conceptual and therefore these are contiguous with those of today only conceptually. Contrarily, the post-1500 theories are contiguous with those of today both conceptually as well as experimentally, for the subsequent evolution of scientific knowledge up to 1900 A.D. was nothing but a chain of experimental discoveries all explainable within a single axiomatic framework.

The heliocentric theory of solar system first proposed by Aristarchus of Samos in defiance of the geocentric theory of Aristotle was revived by Copernicus (1473-1543) on the grounds of its simplicity and mathematical beauty.[1] Copernicus, however, did not support his theory by observations. Thus, it was only a conceptual extension within the earlier framework. A true revolution was affected only by Galileo (1564-1642) whose vigorous criticism of Aristotelian dogmas, not only in the field of astronomy but also in that of dynamics, ultimately succeeded in liberating science from the shackles of argumentation devoid of experimentation.[2] This revolution was brilliantly consolidated by Newton (1642-1727), an English genius. Whereas Aristotelian framework dominated the scene of scientific knowledge for nearly 1800 years, Newtonian framework could do so only for 300 years or so. But the Newtonian framework owes a great deal to two other thinkers: Descartes (1596-1650), a brilliant Frenchman contemporaneous with Galileo and Leibnitz (1646-1716), a German philosopher and mathematician contemporaneous with Newton. Another revolution occurred in 1900 A.D. which brought down Galileo-Descartes-Leibnitz-Newton model. The primary exponents of this revolution were Planck and Einstein. The new framework was articulated and cultivated by a host of thinkers such as DeBroglie, Bohr, Born, Schrodinger, Heisenberg and Dirac etc. However, this Planck-Einstein model has also started to give way within such a short period of 50 or so years. It can, thus be safely guessed that another revolution in natural philosophy is round the corner. The important question, therefore, is how these thinkers contributed to the continuity of the revolutionary process in scientific thought?

2. Galilean revolution derives its importance not only from the fact that it challenged Aristotle's dogma and thus arrived at a new scientific method, but also from the fact that it revolted against the then authority of the church. In his new logic of science, Galileo demanded the supremacy of experimental method over pure speculation; he demanded the method of 'observation of a section of reality'. "At first it will be expedient to find out and explain a definition best agreeing with that Nature makes use of. For though it be not inconvinient to feign a motion at pleasure and then to consider its properties, ... yet because Nature makes use of a certain kind of acceleration in the descent of heavy bodies, we are resolved to search out and contemplate the passions thereof, and see whether the definition that we are about to produce of this our accelerate motion does apply and congrously agree with the essence of motion naturally accelerate."[3] Thus, the method demanded not pure speculation and logical explanation but a continuous striving for an explanation that aptly agrees with the natural occurrences. The essence of revolution, therefore, consisted in this discovery of a new method: by experiments on falling bodies and pendulum, Galileo opened the way to a new science of dynamics; and with the discovery of telescope he established the correctness of the heliocentric theory in astronomy.

As compared to the sincerety and the aggressiveness of Galileo, to his courage in defying the authority of the church, to his untiring efforts for fearless expression and defence of that which is congruous with the ways of nature, the contributions of Copernicus are meagre. Contrary to popular belief, Copernicus was not at all a revolutionary for he restrained himself from expressing what he thought was correct and true. Neither did he make any fundamental contribution to astronomy, for whatever he said had already been proposed. It seems, therefore, that the phrase 'Copernican Revolution' is a misnomer since the personality that emerges as of a true fighter who ignored the miseries to which he was subjected in contrast with the importance of what he was saying, was the personality of Galileo. "I will open the way to a most extensive and excellent science, of which these our labours shall be the elements into which more subtle and piercing wits than mine will be better able to dive."[4] Further, he said, "If someone had held it to be heresy to to say that the Earth moves, and if later verification and experiment were to show us that it does indeed do so, what difficulties would the church not encounter. If, on the contrary, whenever the works and the World cannot be made to agree, we consider Holy Scripture as secondary, no harm will befall it, for it has often been modified to suit the masses and has frequently attributed false qualities to God. Therefore I must ask why it is that we insist that whenever it speaks of the Sun or of the Earth, Holy Scripture be considered quite unfallible?"[5] It is owing to this insistance of Galileo to ascribe supremacy to experimental method in science that nowhere do we find him making ambiguous metaphysical utterances. He, thus, gave science the jolt it most needed, namely by separating the wheat from the chaf: Galileo insisted that physics be separated from metaphysics. He, therefore, instead of employing his reason in the metaphysics of matter, motion and the cosmos, thought it best to employ it in laying solid foundations for the experimental sciences of dynamics and astronomy. His vigorous criticism of Aristotle's laws of motion, of falling bodies, and of the theory of the stable earth as the centre of the universe is well known by now. We, therefore, proceed to examine the contributions of Descartes, Newton and Leibnitz to the furtherance of scientific revolution.

3. Descartes' name is usually associated with a revolution in philosophy, but equally great are his works in geometry and astronomy. It can be said that he was primarily a scientist and metaphysics attracted him 'in so far as it provided a framework for his physics.' Physics, he thought, was nothing more than geometry. But Descartes rejected

the 'slow-going methods' of Galileo, perhaps primarily because of his metaphysical leanings: Descartes remarked, "Without considering the first causes, he (Galileo) sought only for the causes of a few particular effects and thus built without a foundation", and "I see nothing in his books which I envy and almost nothing which I would acknowledge as my own."[6] Descartes insisted on the incorporation of mathematical methods in physics: "That I do not accept or desire any other principle in physics than in geometry or abstract mathematics, because all the phenomena of nature may be explained by their means, and sure demonstration can be given of them."[7] In his voluminous Principles of Philosophy he begins with the problem of acquirement of knowledge, discusses the principles and nature of material things, the problem of vacuum, space, time and motion, and finally deals with astronomy in which he propounds the famous vortex theory of the heavens — here he discusses for the first time in the history of natural philosophy, the concepts of gravity, light, heat etc. The Principles of Philosophy is so exhaustive that rarely can a treatise be found with such scope and breadth. Here Descartes discusses the concepts of infinite/indefinite, substance, mind/body, rarety/condensation, internal place/external place, space/extension, vacuum, motion etc. and thus lays the foundations of theoretical physics. We can now discuss some of these concepts.

"Substance", says Descartes, "is infinite." "By substance we can understand nothing else than a thing which so exists that it needs no other thing in order to exist. And in fact only one single substance can be understood which clearly needs nothing else, namely God. We perceive that all other things can exist only by the help of the concourse of God."[8] In this sense, God alone can be said to be infinite substance since it cannot have any limits, it being perfect and existing independently. This substance can itself *create* substance and created substances are of two kinds: thinking substance and corporeal substance. But how do we know about these created substances? This is possible by our perceiving their attributes and since nothing is possessed of no attributes we conclude that the perceived attributes are necessarily of the substances. These attributes are the principal properties of their respective substances in that these constitute their nature and essence and all the other properties depend on these. The principal property of thinking substances, which he calls mind, is thought and that of corporeal substance, which he names body, is extension in length, breadth and depth. Thus, thought constitutes the nature and essence of mind and extension constitutes the nature and essence of body. All other properties, of thinking or of corporeality, are the modes of these principal properties.

Extension is synonymous with space in that the corporeal substance or body or matter is everywhere. "Space or internal place and the corporeal substance which is contained in it, are not different otherwise than in the mode in which they are conceived of by us.... The difference between them consists only in the fact that in body we consider it as particular and conceive it to change as body changes; in space, on the contrary, we attribute to extension a generic unity, so that after having removed from a certain space the body which occupied it, we do not suppose that we have also removed the extension of that space, because it appears to us that the same extension remains so long as it is of the same magnitude and figure, and preserves the same position in relation to certain other bodies, whereby we determine this space."[9] Also, the notion of vacuum becomes absurd now, for, space and vacuum are the same since if vacuum is a space in which there is no substance, then obviously vacuum will be extended and it is inconceivable that nothing should possess extension. Vacuum, in the Cartesian sense, is that '*place* in which there are none of those things which we expected to find there': vacuum contains nothing perceivable. For the same reason — of extension — it is impossible to have atoms, "for however small the parts are supposed to be, yet because they are necessarily extended we are always able in thought to divide any one of them into two or more parts; and thus we know that they are divisible. For there is nothing which we can divide in thought, which we do not thereby recognise to be divisible; and therefore if we judged it to be indivisible our judgement would be contrary to the knowledge we have of matter."[10]

Now, matter is found to have variety of forms and figures and magnitudes. Is this diversity intrinsic to matter? What is the cause of this diversity? Descartes answers that there is but one matter in the whole universe because it is extended. This extended matter can be divided into parts and these parts acquire motions — motions caused by God. The diversity therefore, is due to different motions possessed by different parts. The parts will be hard or fluid depending on the kinds of motions they had — circular or vortex or rectilinear motions. The world is the totality of corporeal substance and is extended indefinitely. Because of the uniformity of matter everywhere, the plurality of words is inconceivable. "Thus the matter of the heavens and of the earth is one and the same, and there cannot be a plurality of worlds."[11] Further, "All the properties which we clearly perceive in it may be reduced to the one, viz., that it can be divided, or moved according to its parts, and consequently is capable of all these affections which we perceive can arise from the motion of its parts. For, its partition by thought alone makes no difference to it; but all the variations in matter, or diversity in its forms, depends on motion".[12] And motion is nothing but transportation, it is always in the mobile thing not in that which moves it. Motion is not a substance but a mode of the mobile thing. Movement and rest are nothing but two modes of a body in motion. No greater action is required for movement than for rest. "Motion is the transference of one part of matter or one body from the vicinity of those bodies that are in immediate contact with it, and which we regard as in repose, into the vicinity of others".[13]

With such understanding of matter as fluid as well as hard, depending on the motion that it has, Descartes built his mechanical model of the universe. In the beginning was created the fluid matter which was endowed with motion by God. The whole universe is nothing but an interplay of different parts in vortex motion. Our own solar system is a huge vortex in the centre of which is the sun. The planets in it are not mobile by themselves but are carried by the vortices of the fluid. This mechanical theory, though inadequate in many respects and contrary to the mathematical spirit of Cartesian method, was indeed an ingeneous astronomical theory.

Also, Descartes' contribution to dynamics consisted in formulating his laws of motion when, for the first time, he vaguely discussed the now well known third law of motion. Here he also delved upon the question of impact of two bodies and the nature of dynamics thereupon. His theories of magnetism and light built upon the vortex theory of the fluid matter were again ingeneous: the former he explained as resulting from directionality of vortex motion and the later as resulting from the pressure transmitted through space from the luminous body.[14]

We know today that the theories of matter as developed by Descartes, though were by no means lacking ingenuity, were singularly lacking rationality. "To invoke divine immutability as the guarantee of the soundness of his 'rules' was unworthy of one whose aim was to explain the workings of the cosmic machine mathematically. Had he been content to learn from Galileo instead of being at such pains to disparage his works, it is impossible to imagine what heights he would have scaled".[15] And therefore, at least in this sense, Descartes made a reaction, but he unwittingly furthered the Galilean Revolution by emphasising with equal vehemance — as that of Galileo for the experimental method — the importance of mathematical method not only in physics and astronomy but also in disciplines such as philosophy.

4. As a successor of Galileo and Descartes, Newton was the inheritor of a physics that had, in the course of its advancement, acquired two very powerful working tools: Galileo had given it the experimental method and Descartes had given it the mathematical method. Thus, with these two powerful methods at hand, Newton embarked on build-

ing up a systematic mechanical model of the universe which was to guide physicists and philosophers alike for nearly 300 years — and here Newton has been second only to Aristotle. This new synthesis of Newton was given the name of 'experimental philosophy' and its importance was clearly recognized by the learned men of those days. . "They proceed therefore in a twofold method, synthetical and analytical. From some select phenomena, they deduce by analysis the forces of nature and the more simple laws of forces; and from thence, by synthesis, show the constitution of the rest. This is that incomparably best way of philosophising. . . ."[16] Newton's "Mathematical Principles of Natural Philosophy" was undoubtedly a landmark in the history of philosophy — it laid down in clear terms the acceptable rules of reasoning and method of experimental philosophy. The four basic rules of reasoning that were to be followed strictly were: "to admit no more causes of natural things than such as are both true and sufficient to explain their appearance; to the same natural effects, we must, as far as possible, assign the same causes; the qualities of bodies, which admit neither intensification nor remission of degrees, and which are found to belong to all bodies within the reach of our experiments, are to be esteemed the universal qualities of all bodies whatsoever; in experimental philosophy we are to look upon propositions inferred by general induction from phenomena as accurately or very nearly true, notwithstanding any contrary hypotheses that may be imagined, till such time as other phenomena occur, by which they may either be made more accurate or liable to exception".[17] As should be clear, the impact of the first rule was to eliminate all metaphysical speculation from physics; the second and third rules ascribed to physics a universal nature; and the fourth rule guaranteed the supremacy of the experiment realising that no logical hypothesis could be absolutely true once and for all. The impact of this Newtonian spirit in method was universal and everlasting. The emphasis on mathematical and experimental methods naturally gave rise to a tendency for quantification, for it is inevitable whenever measurements are made. Newton, therefore, talked of quantity of matter and quantity of motion which concepts he used to great advantage in his three laws of motion. Another concept, perhaps central to Newton's mechanical theory of experimental philosophy, was the concept of 'force' with its variations inertia, mass, and gravitation. Apart from these, Newton sharpened the concepts of 'place', 'space' (in the spirit of Euclidean and Cartesian geometries), 'time', and 'velocity'. With all these concepts thus sharpened, Newton developed a very powerful synthetic system of dynamics — celestial as well as earthly.

Newtonian space and time are immovable, immutable, unchangeable. Parts of space are ordered, one after the other, so are the parts of time, i.e., they have their *places*. To move a part out of its place — whether in space or in time — is to move them 'out of themselves'. "For times and spaces are, as it were, the places as well of themselves as of all other things. All other things are placed in time as to order of succession and in space as to order of situation. It is from their own nature that they are places; and that the primary places of things should be moveable is abusurd".[18] An immovable space is required for explaining motion. Thus, ". . . . all motions, from places in motion, are no other than parts of entire and absolute motions; and every entire motion is composed of the motion of the body out of its first place, and the motion of this place out of its place, and so on until we come to some immovable place . . . . .".[19]

How, then, to measure absolute space, time, and motion? And, how, for instance, to distinguish true from relative motion for a body can be in relative motion without actually moving with respect to the absolute space? The answer to the latter question is that the true motions can be measured by measuring their causes, i.e., forces; and that the apparent motions are in fact nothing but differences of true motions. Regarding the first question: so far as the use of space, time, and motion is concerned, only the relative ones are to be preferred, 'but in philosophical disquisition we ought to abstract from our senses, and consider things themselves distinct from what are only sensible measures of them, for it may be that there is no body really at rest, to which the places and motions of others may be referred".[20]

5. If we compare him with Descartes, Leibnitz seems to possess greater metaphysical tendency, nevertheless he reached much closer to present day physics than perhaps any of his predecessors or contemporaries. Leibnitz, in his philosophy, sought to explain both the bodies endowed with consciousness and without consciousness. His whole philosophy seems to be permeated with four fundamental and what he likes to call, 'great' principles: (i) Principle of the perfection of God,— that God, a perfect Being, created things that always approximate its perfection; (ii) Principle of the identity of indiscernibles,— that no two things in Nature can be identical, internally or externally; (iii) Principle of contradiction,— that what implies a contradiction cannot be true and therefore is false; (iv) Principle of sufficient reason,— that 'nothing exists without a sufficient reason why it is thus rather than otherwise'. Leibnitz used these principles with great ingenuity while taking issue with Cartesians on the question of extension being the essence of matter; and with Newtonians on the question of the absoluteness of space and time; and in general in his Monadology and Specimen Dynamicum.

According to Leibnitz, real entities are those that are simple and imperishable — those that cannot be changed by any external influence. These atomic entities can either be conscious in which case they be called souls; or without consciousness, in which case they are souls-without-consciousness:—for both of them a common name is *monad.* According to the Principle of identity of indiscernibles, since no two things that exist are indiscernible, each monad differs from another. But these must possess some quality, otherwise they will be unknowable. Thus, God has endowed them with force by virtue of which they are always active. But how these monads *interact* with each other since they are simple? "A substance", says Leibnitz, "which is of infinite extent inasmuch as it expresses everything, becomes limited by the mere perfect or less perfect manner of its expression. It is thus that one can conceive that substances hinder or limit one another and are compelled, so to speak, to accommodate themselves to one another. For it can happen that a change which augments the expression of the one diminishes that of the other".[21] These monads, being nothing but simple substance, are without parts. They can only begin and end all at once, that is to say, 'they can only begin by creation and end by annihilation, whereas what is compound begins or ends by parts'. Obviously the simple substance of Leibnitz is atomic. But he actually refutes the possibility of atoms as well as of the void. Matter, says Leibnitz, is a plenum. "All bodies form a coherent whole. All are separable by force from the others, but not without resistance. There are no atoms or bodies whose parts are never separable by force".[22] For his argument against void and atoms we must reproduce here a lengthy excerpt as it will also show with what ingenuity he used his principles: "Actually the least corpuscle is subdivided *ad infinitum* and contains a world of new created things, which the universe would lack if this corpuscle were an atom, that is, body all of a piece and not subdivided. All the same, to want to put a void in nature is to attribute to God a very imperfect producion, it is to violate the great principle of the necessity of a *sufficient reason*. . . . I assume that any perfection which God could put in things without derogating from the other perfections in them, has been put there. Now, let us imagine a space entirely empty; God could put in it some matter without in any way derogating from anything else whatever; therefore, he did put some matter therein; therefore there is no space entirely empty; therefore everything is full. The same argument proves that there is no corpuscle which is not subdivided".[23]

Leibnitz discusses at great length the concepts of force, space, time, and motion in his 'Specimen Dynamicum'. Force is the effort in the body which, 'were it not limited by a contrary effort, would come to realisation'. Force is not mere "potentiality", it is either *active* or *passive*. Each of them exists in two forms: *primitive* and *derivative.* Derivative force is only a limitation of primitive forces, 'arising from a multiplicity of conflicting interactions of bodies. This primitive active force is what is *substancial form* or *soul* and 'pertains only to general causes which do not suffice for explanation of phenomena'. Primitive passive force, on the other hand, is the persistent force of resistance in the bodies and constitutes the "primary matter" of scholastic philosophy. It is by virtue of this force that one body cannot be penetrated by another. The derivative passive force is the force of persistence (or inertia) which reveals itself in many ways in secondary matter."... having once established that every body *acts* by virtue of its *form*, and is persistent or offers resistance by virtue of its matter, we wish to proceed to the further problem and to deal with the theory of derivative forces and resistances".[24] Thus, force must always be conserved. "A body which pushes another along must therefore always suffer a retardation such that neither more nor less force is contained in the effect than in the cause. Since this law cannot be derived from the merely geometrical concept of mass, there must be another basic principle immanent in bodies, viz., the force itself which is always preserved in the same quantity, although it is divided among dfferent bodies".[25]

Space and time, says Leibnitz, are purely relative. Space is an order of coexistence and time an order of successions. Space is neither a substance nor an absolute being, nor an organ of God. Space is absolutely uniform and 'without the things situated in it, one point of space absolutely does not differ in any respect from another point of space'. "Now, from this it follows that if we suppose that space is something-in-itself, other than the order of bodies among themselves, it is impossible that there should be a reason why God, preserving the same positions of bodies among themselves, should have arranged bodies in space thus and not otherwise. But if space is nothing other than this order or relation, and is nothing whatever without bodies but the possibility of placing them in, these two conditions, the one as things are, the other supposed the other way round, would not differ from one another, their difference exists only in our chimerical supposition of the reality of space in itself. But in truth the one would be just the same as the other, as they are absolutely indiscernible and consequently there is no occasion to search after a reason for the preference of the one to the other. The same is true for time".[26] It immediately follows that, since space and time are not real, motion is also not real. Since it does not possess any coexisting parts just like time, it has no existence as a whole. "And thus there is nothing real in motion itself, apart from the reality of the momentary transition which is determined by means of force and an effort for change".[27]

Since the Newtonian model prevailed in spite of Leibnitz, who sounds extraordinarily modern so far as the recent developments in physics are concerned, it seems he could not fight single handedly the well established experimental philosophy of Newton. Today we know that the notions of space, time, and motion, of the Newtonian scheme had to be abandoned altogether. Today, we are asking anew: are, in fact, space and time mere notions?

6. The history of the success of Newtonian-Leibnitzian model is well known. Newtonian mechanics was widely applied to various phenomena and it proved amazingly successful in most of them. But it failed completely in explaining the phenomenon of light; and the phenomenon of heat too could not be fully understood.[28] It was, however, continuously developed in the form of mechanics of rigid bodies where the forces, masses, and motions of tiny particles constituting the rigid body were simply summed so as to find the mechanics of the whole body. This corpuscular-kinetic view was a natural consequence of the Newtonian framework and it in no wise challenged any of its fundamental axioms.

In a sense, Newtonian mechanics was a systematic embodiment of the atomism of Leucippus and Democritus. And the concepts that were adopted had to face the only two criteria: of logical conformity with the existing theory, and of measurement. But the logic of the theories was also to be confirmed by measurement albeit the objects of measurement were not these subtle atoms which had definitely found their place in the mathematical framework. It was never the aim of Newtonian framework to measure the motions and masses of those very particles which appeared in the corpuscular-kinetic theories: their aggregates alone were the object of measurement. And this was precisely the limitation of Newtonian framework.

When Newtonian mechanics did not succeed in explaining some of the phenomena of light and heat, these were excluded from the category of matter. Light was considered a manifestation of wave-motion in an elastic medium and heat (caloric) was thought to be 'some kind of imponderable fluid which was strictly conserved'. And the amazing thing of all was that the physicists of that period did not expect much from these phenomena and they thought that all that was to be known had been known and what was further needed was to achieve an accuracy to a greater number of decimal places in the results already obtained!

As these problems matured, efforts were made to measure the velocity of light, and a new phenomenon known as 'heat radiation' came to the notice of some German physicists. So far as light phenomenon was concerned, Newtonian mechanics demanded that although its true motion would be that which is relative to absolute space, in different frames it should have different relative motions. But experiments by Michelson and Morley revealed that the velocity of light remained constant in every frame and every direction. This was in obvious contradiction with the Newtonian model and eminent physicists of those days, like Lorentz, tried to explain the experimental evidence so as to reconcile it with the Newtonian model. Einstein, however, accepted the truth of this fact, namely, that the velocity of light remains constant in any frame and in any direction. With the additional assumption that no material body could transcend this limiting velocity, he developed his theory of relativity[29] which forced a fundamental revision of all the basic concepts in the Newtonian model. These concerned motion, mass, space and time. With the new concepts as foundation, Einstein further developed his theory so as to make it 'general'. Newtonian model could not be saved. And undeniably, Einstein had effected a revolution in scientific thought.[30] In the direction of the phenomena of heat radiation, it was becoming increasingly difficult to develop a theory that would precisely explain the proportionality relation between the intensity of radiation as against its frequency and temperature,— as discovered in the experiments on 'black body'. Planck[31] finally succeeded in giving a mathematically derived expression which excellently tallied with the experimental data. He, however, had to make certain assumptions which were also contray to Newtonian spirit. However, it was also found to give correct results when applied to other phenomena such as photoelectric effect and gas ionisation. This showed that Planck's idea was not only correct but a revolutionary one too. To this turbulance in physics which occurred in the first decade of the 20th century, we give the name Einstein-Planckian Revolution: it was indeed as significant, as was to be proved later, as that made by Descartes and Galileo in respect of both experimental and logical methods.

7. The story after this is well known. Realising the importance of Planck's discovery, physicists sought to explain every micro-phenomenon on these lines. Thus, the phenomena of heat ionization, electricity, magnetism were successfully explained. Bohr[32] sought to explain the observed spectra of gases by presenting a model of the atom, i.e., of the particle which in Newtonian physics was rigid and compact and structureless. He had worked out on Planckian line and his theory was fairly successful but not entirely so even for the simplest hydrogen atom. DeBroiglie[33] independently sought to take the duality of waves *as* particles to its natural conclusion, i.e., he asked: if light can behave as a quantum oscillator, i.e., as a particle, then why particles should not behave as waves? He, thus, advanced a wave theory of atom in which he accounted for the relativistic velocity of the electron in an orbit. This theory stood to

experimental confirmation. Subsequently, Heisenberg[34] and Schrodinger[35] advanced their Quantum Theories: the former arguing that the concept of *velocity* of electron in the orbit must be abandoned since it cannot be measured by any experiment whatsoever, and instead of that the concept of *frequency* should be adopted; the latter again giving a model of atom as a 'particle', i.e., nucleus diffracting in a cloud of electron waves. With these theories as the base, it became possible to develop more refined theories which made a penetration of atom a reality. Thus, it has gradually become possible to develop a spectrum of what are called 'elementary particles' in about the same manner in which Daltonian chemistry developed a periodic table of the elements and Maxwell's equations developed a spctrum of visible light. Highly refined techniques have made even the penetration of these elementary particles possible. But we are lacking a comprehensive theory of these particles which would explain why their number is as much as it is, how they are formed, and so on? It is hoped that some crazy idea, such as Planck, will make such a theory possible!*

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NOTES

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