OPINION

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ALBERT EINSTEIN

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On the 18th April came through Reuter news which plunged the entire scientific world into deep sorrow. Albert Einstein, the great philosopher scientist had suddenly died in a hospital. Einstein had been in indifferent health for some time. But all his admirers had hoped tha t he would be yet with them for a few more years to guide all who toil to achieve the great synthesis that he had dreamt of and for which he had devoted his entire life.

The scientists would assemble in Berne this year in July to celebrate the fiftieth anniversary of the discovery of the Theory of Relativity. They had hoped Einstein himself would attend and tell them of the latest results he had obtained. He had continued to work on his favourite topic, the Unified Field Theory, till the very end. But the great teacher is now no more. The great source whence sprang so many revolutionary ideas which shaped the course of present day physics has now stopped for ever.

Born in 1879 in a small Swabian Jewish community Einstein had his first lessons in the humanistic gymnasium at Munich. The family went over to Italy when Einstein was still young, and the studies of Einstein were finally completed at the Federal Institute of Technology at Zurich. He worked most of the time at the experimental laboratory of physics. The direct contact with experience had for him the greatest of fascination. His knowledge of theoretical physics was however derived mostly from the study at home of the great works of Kirchhoff, Helmholtz and Hertz. The famous 'History of Mechanics' by Ernst Mach had also a profound influence on him and strengthened his critical instincts which led him ultimately to formulate his famous Theory of Relativity. The inconsistency of the basic assumptions of classical mechanics with Maxwelrs Electromagnetism had begun to trouble him even when he was a young student of 17.

But the discipline of classical Thermodynamics had left a deep and permanent impression, and late in life, in his auto-biographical notes he had written that it was the only physical theory of universal content which, he was convinced, would never be overthrown.

His earliest papers were on the application of thermodynamics. The first paper, on Capillary phenomena, was published in 1901. Further brief notes on the applications of thermodynamics followed. Einstein had now begun to work at- the Patent Office in Berne. Away from a proper academic atmosphere, he continued to work in isolation, and by 1905 was ready with his paper on *Electrodynamics of Moving Media* which ushered in the special relativity theory and revolutionized the fundamental concepts of space and time.

The famous experiment of Michelson had brought about a crisis in contemporary physics. Fresnel had explained light as wave motion in ether, a medium which pervaded all space and remained at rest, through which moved Earth and other heavenly bodies. Was it possible to estimate earth's instantaneous velocity as it sped along its orbit round the sun, by careful optical experiment? Ordinary experiments on reflection and refraction in the laboratory with apparatus oriented along various azimuths had failed to detect any difference. Fresnel had satisfactorily accounted for this negative effect by assuming that a portion of ether remained ever locked up in matter and moved with it. The density of this portion of ether locked in matter wou1d remove all first order effects automatically. There remained however the possibility of minute differences, which Michelson hoped to detect with his mter-ferometer. His experiment was boldly conceived and carefully carried out. The negative result which persisted, had brought about this crisis.

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Albert Einstein at the Swiss Patent Office in 1905, the year of his greatest productivity.

A radical revision of our ordinary ideas seemed necessary. Fitz-gerald had suggested that all material bodies would contract and change their linear dimensions in the direction of its drift through ether. The fundamental researches of Lorentz on the electromagnetic equations of Maxwell had indicated that perhaps a revision of our time concept was needed to escape this theoretical impasse. Lorentz had introduced for moving bodies a new canception, a local-time, which apparently, secured an approximate invariance of the basic equation of electromagnetism, when set up in terms of co-ordinates fixed in moving bodies. An exact invariance of the fundamental equations was however needed to rescue the optical theories from this dilemma.

At this stage Einstein's paper appeared as a revelation. By a sharp critical examination of the fundamental basis of measurement of Space and Time, Einstein had found the answer to this riddle.

All descriptions of physical phenomena would require a frame of reference fixed relative to the observer who notes where the events happen; he has also to note when they occur for which he has to evolve his own way of measuring time. In his fundamental laws of motion, Newton had admitted the equivalence of frames, moving relative to one another with constant relative velocities. This motion apparently had no effect on the ultimate explanation of natural phenomena, in terms of his dynamical laws. Time however occupied a special position in his system. Ideal clocks which served to mark time for the different observers moving relatively to one another, would, according to him, all go at the same rate, and thus provide a unique canvas, against which all observers could note their observations. Einstein showed this concept of time to be an untenable hypothesis. The invariant quantity should be not time, but the velocity of light signals which helped each observer to set up his time standard everywhere in the space-frame in which he happened to be at rest. This simple hypothesis led at once to the famous transformation-laws of space and time coordinates. It was also the exact formulation of the approximate laws which Lorentz had discovered earlier from his profound studies of electromagnetic laws, and curiously enough also gave a reasonable basis to the Fitz-gerald contraction hypothesis. This alone would have been an immortal achievement; but Einstein of 1905 was big with other revolutionary ideas. By a successful application of his favourite thermodynamical laws he discovered and published fundamental relations about the Brownian Motion, which helped Perrin to demonstrate the reality of the atoms. In 1905 even before he had launched his special relativity theory, he had published the famous photo-electric equations, based on light quantum hypothesis, which won him the Nobel Prize of 1921.

By 1900 Planck had arrived at his famous law of black-body radiation. Radiation imprisoned in an enclosure at constant temperature, had always a unique energy spectrum. This experimental fact called for explanation. By a masterly application of the laws of thermo-dynamics Planck had been able to explain the phenomena satisfactorily, but the explanation had one disconcerting feature. Instead of steady and continuous interchange of energy as postulated by the classical theory, exchange seemed to take place in jerks, between the radiation-field and the Planck's resonators.

A discontinuity had to be introduced somewhere for a successful deduction of the famous law. But it seemed to go against all current conceptions of Physics. While Planck hesitated before this dilemma, Einstein gave now a truly revolutionary lead. He had found that the phenomena of emission of electrons from metal plates also gave evidence of the same discontinuous process, and he boldly came forward with his light-quanta hypothesis. Energy in the wave of light was not continuously and uniformly distributed but there were bundles of energy quanta, distributed throughout the field, which can only be abstracted as a whole unit from the system and absorbed or re-emitted in the same way as one discrete unit of energy of a monochromatic frequency. Thus he arrived at his famous photo-electric equations. Thus were launched almost simultaneously the two revolutionary concepts which have changed the face of modern physics. The soil was ready and his ideas bore quick fruit. They were readily accepted and developed. Minkowski built up the special relativity theory in his world-geometry of four-dimensions and ushered in the age of Tensor calculus in Physics. Time and space concepts were thus indisssolubly linked together. Simultaneously other physical concepts underwent fundamental revision.

Einstein demonstrated the equivalence of mass and energy. The revision of time concept had made changes in the fundamental dynamical laws of Newton, necessary. Mass ceased to appear as an invariable characteristic of the particle. It had to change when the energy of the particle changed, and conversely the mass of the particle gave an idea of the total energy locked in it. All fundamental particles had thus according to Einstein tremendous reserves of energy. This has proved to be the cornerstone of recent nuclear studies. Now-a-days, atoms can be disintegrated and compelled to deliver tremendous amount of energy during the process. Einstein's relation

$$\Delta mc^2 = \Delta E,$$

however, is found to be true in all cases of transformation.

Light quanta hypothesis had also made tremendous progress, during all these years.

In 1913, Bohr published his quantum theory of the atom; Einstein's light quanta had given the key to the emission and absorption of radiation by atoms and molecules. Einstein himself had studied thermodynamic equilibrium between black-body radiation and a gas, and revealed the connection between Planck's formula and Bohr's law of frequencies. He had there introduced his famous conception of transitional probabilities, which hold the field even now in all quantum mechanical calculations.

In 1924, Bose succeeded in deducing Planck's law by introducing a new statistics which Einstein accepted and applied in the Kinetic Theory of Gases to explain low temperature behaviour of gases.

Academic recognition also had come quickly to him; soon after the publication of his relativity theory he was appointed Associate Professor at the University of Zurich. Subsequently he went to Prague as full Professor and returned a few years later as Professor in the Institute of Technology at Zurich. A little before the First World War he was called to Berlin as a research Professor. This finally gave him the leisure he needed to develop further his favourite relativity theory.

His special relativity theory is based on the equivalence of all systems moving with constant relative velocities. It had clothed the Electromagnetic Theory of Maxwell and Lorentz with a new significance. But accelerated systems had to be kept out of the scheme. Einstein had however the intuition that natural laws should be capable of formulation in a more general manner. He was convinced that the special relativity theory is only the first-step in a necessary development and this became increasingly clear to him as he attempted to represent gravitation within the frame-work of his theory. Mter a lot of hard thinking it came; to put it in his own words: The fact of the equality of inert and heavy mass *i.e.* the fact of the independence of the gravitational acceleration of the nature of the falling substance may be expressed as follows. In a gravitational field things behave as they do in a space free of gravitation when in place of an inertial system a reference system accelerated with reference to the inertial system is introduced. This led almost to a solution in 1908. Deep thinking however convinced him that for full success of his ideas he had to give up also the Euclidean space and introduce instead curved space of Riemann where the curvature is conditioned by the presence of the masses themselves. He thus arrived by 1915, at his famous generalised Relativity Theory of Gravitation. The space time continuum of the special theory has become non-Euclidean in Riemann's sense, and it has received a curvature impressed upon it by local energies. It also delivered results capable of experimental verification. In 1919, the British Solar Expedition announced an important verification that light rays do get bent in sun's gravitational field. Of the two other major results, the perihelion motion of mercury seemed to come out correct from the new theory (a correction on the results of Newton). The red shift of lines has also been claimed to have been verified in the spectra of light from certain extra-dense stars.

This success had stimulated Einstein for further endeavours. He had dreamt of a crowning synthesis which would explain electromagnetism and gravitation, and would also account for the fundamental particles which constitute matter. For him all the present theories had remained incomplete.

Maxwell's theory for example, is unable to set up laws for the behaviour of electrical density without which there cannot be any electromagnetic field. The general theory of gravitation has similarly furnished a field theory of gravitation but no theory of field-creating masses.

While he remained in his later years engrossed in his self-imposed task, the new branch of quantum mechanics had rapidly grown up into an imposmg structure. However the positivistic attitude of the new theory has never been accepted by Einstein. He has been engaged in frequent controversies with the able exponents of the new theory and has always expressed his conviction that the present quantum-mechanics is at best a temporary phase in the development of physics, which he hopes will be later replaced by an all embracing generalisation. Thus he has continued in his own way ever seeking for newer and bolder generalisation seeking for a Unified Field Theory till almost to the last day of his life.

The importance of Einstein's achievements has been ably summed-up in a recent article by Louis De Broglie: "The first half of the ·twentieth century was marked by an extra-ordinary impetus to Physics which will remain one of tbe most brilliant chapter in the history of science. In these few years human sciences raised two monuments which will stand for centuries: the theory of relativity and the quantum theory. The first emerged wholly from the creative brain of Albert Einstein. The second whose first stones were laid by Planck, owes to the mind of Einstein some of its most noteworthy advancement".

During the upheavals between the two World Wars Einstein suffered much. In 1933 he was forced to leave Berlin and robbed of all his possessions. He had to migrate to America where he has passed the last years of his life. Throughout his life he was however a fearless exponent of what he believed to be true. His indomitable will never bowed down to tyranny, and his love of man often induced him to speak out unpalatable truths which were some times misunderstood. Everyone however paid homage to his wonderful personality and his name would remain indissolubly linked up with all the daring achievements of Physical Science of this era, and the story of his life, a dazzling example of what can be achieved by pure thought. ❐