OBITUARY

Prof. Albert Einstein, For.Mem.R.S.

EINSTEIN was unquestionably the most famous scientist of modern times. There can be little doubt that he was also the greatest and that he was one of the very great thinkers of all time. He changed some of the most fundamental concepts in our thought about the physical world; to very few has it been given to do this. What was most significant in his work may appear simple and inevitable in retrospect; but it resulted from his having questioned some of the universally accepted physical assumptions that no one had ever challenged before.

Albert Einstein was born of German Jewish parents on March 14, 1879, at Ulm in Württemberg. He was educated at schools in Munich and at Aarau in Switzerland, and at the Federal Polytechnic School in Zurich. Having failed to obtain a teaching appointment, he found employment in the Swiss Patent Office in Berne. While holding a junior position there during 1902–8 he produced much of his most remarkable work, and an international gathering of scientists will meet at Berne this summer, at the invitation of their Swiss colleagues, to celebrate the jubilee of relativity theory. It is to the credit of the scientific world of the time that Einstein's early work was so readily published and given recognition. He was appointed successively *Privatdozent* in Berne (1908), extraordinary professor in Zurich (1909), professor of theoretical physics in Prague (1911), professor of theoretical physics in Zurich (1912) and director of the Kaiser Wilhelm Physical Institute and professor in the University of Berlin (1913). In 1933, when his position in Nazi Germany had become untenable, he accepted a professorship at the Institute for Advanced Studies in Princeton, which he held until his retirement in 1945, having meantime become an American citizen. He died at Princeton on April 18. In 1952 he had declined an invitation to become president of Israel. Einstein's first marriage, to Mileva Maritsch, by whom he had two sons, was dissolved, and in 1917 he married his cousin, Elsa Einstein, who died in 1936. He was awarded the Nobel Prize for Physics in 1921, the Copley Medal of the Royal Society in 1925, and very many other honours.

From an early age, Einstein had an unerring discernment of the fundamental problems in physics and a determination to devote himself to them. He was able to see ahead, even if only in broad outline, the main stages of what he set himself to achieve. In the tactics of research he was an opportunist, as in the help he got (and acknowledged) from Minkowski's geometrical ideas and from Ricci and Levi-Cività's tensor calculus, as well as in developments suggested by his own work. But he had a strategic plan that was all his own and to which he adhered. Although each of his major achievements was astonishingly complete in itself, in his view it was the gain of a limited objective that was to serve as a base for the next advance.

Einstein started his scientific work with a realization of the inadequacies of Newtonian mechanics both in its own fundamental formulation and also as a basis for physical theory in general. Many of the considerations were well known, but what impressed Einstein most was the fact that the rudimentary concepts of mechanics and of electrodynamics are so different. Moreover, about this time, Planck had given his theory of temperature-radiation and energy-quanta, and Einstein saw that it involved fundamental contradictions of both classical mechanics and electrodynamics.

The basic notion of electrodynamics is the 'field' and of mechanics it is the 'particle'. In the perplexing situation of those days and ever afterwards, Einstein expected progress to result from the further development of 'field-theory', or of the 'electromagnetic foundation of physics' as he called it, obviously using the expression in a very general sense. But he knew that he must always look for ways of accommodating the 'particle' aspects of physics.

Of all existing physical theory at that time, only classical thermodynamics seemed secure within its own domain and to offer a safe starting-point for fundamental investigations. So it was natural that Einstein's first papers (1901–5) should be on that subject and in particular on its statistical formulation. This led to his famous discovery (1905–6) of the true nature of Brownian movement as a manifestation of the heat-motion of 'molecules', a notion which it crucially vindicated, and his demonstration of the consequent possibility of determining molecular dimensions.

Einstein then observed that a mirror suitably suspended in an enclosure of temperature-radiation ought, in principle, to possess Brownian movement with mean energy appropriate to the temperature. This he showed to be incompatible with electromagnetic wave theory. On the other hand, he was able to show that it is consistent with the hypothesis that radiation of frequency ν interacts with matter, and is propagated, only in whole quanta of energy $h\nu$, where h is Planck's constant. He had already realized that this hypothesis would explain the observational properties of the photoelectric effect. These ideas he developed in his paper of 1905, which presented the concept of light-quanta in the form employed ever since. It freed Planck's ideas about energy-quanta from association with real or hypothetical oscillators and transformed the concept into one having universal physical significance. In this paper, Einstein also suggested that the wave-character of radiation could be treated as a statistical feature of its corpuscular character. Natural though this suggestion may have been, it was the first step towards reconciling the wave and particle aspects of physics, and so towards modern quantum mechanics. But Einstein called all this merely a "heuristic viewpoint".

He was convinced that true progress depended upon starting much further back. He set himself to find a new principle on the model of the thermodynamic principle requiring the laws of physics to be such that it is impossible to achieve perpetual motion of the 'first' or 'second' kinds. He recorded that it took him from the age of sixteen to twenty-six to find it in the form, coupled with the assumption of the constancy of the speed of light, requiring the laws of physics to be such that it is impossible to detect uniform motion relative to an inertial frame of reference (save, of course, by direct observation of the frame). The paper, also of 1905, in which Einstein developed the consequences of this principle could even to-day be given to a student as probably the best summary of the theory of (special) relativity. Remembering his preoccupation with the electromagnetic foundation of physics, it may be recalled that the title of the paper is "On the Electrodynamics of Moving Bodies".

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Many features of the theory had been foreshadowed by other workers. In Einstein's intensely original presentation, these features fell into place in a system based upon a single principle. Moreover, Einstein saw a significance in the work that was beyond the range of vision of his predecessors. Their merit was in having so exposed the difficulties of the matters concerned that the magnitude of Einstein's achievement could the more readily be appreciated.

It was another ten years before Einstein attained what was almost certainly his greatest triumph, the theory of general relativity. The restrictions in the scope of the special theory are well known, as are also some of the considerations, particularly in regard to the equivalence of inertial and gravitational mass, that guided Einstein in removing the restrictions. He was guided also by Minkowski's geometrical formulation of special relativity. But in general relativity the geometry of space-time and what is happening in space-time are interdependent; hitherto it had been universally assumed that space-time had an independent existence. If ever any single advance may be called epoch-making, this is one that must earn the description. In whatever way physical theory may develop in the future, it cannot be believed that this step will ever be retraced. For it is easy to recognize that the behaviour of clocks, measuring-rods and light-signals must be related to the behaviour of the physical system of which they form part. It had previously been implicitly supposed that there nevertheless exists an underlying space-time that can somehow be 'explored' by the use of the measuring-rods, etc. In effect, Einstein showed the emptiness of this concept. When we consider what we call the spatial and temporal relationships of a physical system, we are concerned with aspects of its behaviour that cannot be conceived in separation from its other aspects.

It was one thing to appreciate the advance that was needed; it was another to give it mathematical expression. Einstein accomplished this in brilliant fashion in the limited domain of the 'general' theory. For he regarded this as being satisfactory only in its treatment of a pure gravitational field. He described as only 'makeshift' the way in which he introduced the matter-tensor. According to his view, in this provisional state of the theory, material bodies are essentially regions where his gravitational field-equations ($G_{\mu\nu} = 0$) are not satisfied, and so, in this sense, the bodies are singularities in the field. In 1938 and succeeding years, Einstein and his collaborators improved upon the original formulation of the theory to the extent of showing that the motion of such singularities in each other's presence is determined by the field-equations alone. Thus general relativity has no need to postulate equations of motion in addition to the field-equations, by reason of the non-linearity of the latter. However, Einstein's ultimate aim was to obtain field-equations such that actual physical systems correspond to solutions free from singularities. He believed this would be possible if, and only if, he could represent all physical forces, electromagnetic and nuclear as well as gravitational, in the theory—hence the name 'unified field theory'. If successful, such a theory would account for the existence of material particles in terms of the field and so, in the most fundamental manner that Einstein could envisage, it would reconcile these aspects of reality. In doing so, he further believed, it would reproduce 'quantum' effects, but without the need for the statistical interpretations to which he objected in current quantum theory. After various discarded attempts, he thought the field-equations which he proposed in 1949–51 to be "the most natural generalization of the equations of gravitation". Whether these equations possess solutions free from singularities has not yet been determined.

The problem of unifying the basic concepts of physics has, of course, the importance that Einstein thought. However, most physicists expect it to be solved rather by a generalization of quantum theory than by the opposite approach attempted by Einstein. His view and comments by its leading critics are to be found in "Albert Einstein: Philosopher Scientist" (edit. P. A. Schlipp, New York, 1949, 1951). Here it need only be said that Einstein's position should be judged only in the light of his doctrine of concepts as being "freely chosen conventions".

Besides the main development of his work, Einstein made numerous other important contributions. These include, for example, the 'Einstein coefficients' in connexion with atomic transition-probabilities, his work from which the Einstein–Bose statistics emerged, and his enunciation of the 'Einstein universe' and other contributions to relativistic cosmology.

Einstein was deeply and increasingly concerned about world affairs. In the First World War he took a courageous stand as a pacifist in Germany. However, he could not but approve of the war against Nazism, and in 1939 he sent a historic letter to the American President warning him that Germany might succeed in manufacturing an atomic bomb. He became a leading spokesman for Jews throughout the world, particularly in regard to their return to Palestine. He was for long an advocate of world government. His opinions on these matters and his attitude towards philosophy and religion are expressed in the collection of essays "Out of my Later Years" (New York and London, 1950).

Einstein's gifts inevitably resulted in his dwelling much in intellectual solitude. While he was not sociable in the usual sense, he had a penetrating understanding of his fellow-men. Music played a great part in his life, and the satisfaction it gave him he gladly shared with his friends. The many tributes paid to his personality all testify that his moral stature matched his intellectual pre-eminence.

W. H. McCrea

My first contact with Einstein was at the eighty-fifth meeting of the German *Naturforscherversammlung*, held in Vienna in September 1913, when I was a postgraduate student in the Radium Institute there. In his usual attractive and friendly manner, he lectured to the Physics Section on "Gravitation", and his lecture quite obviously impressed most of his hearers as the work of a master-mind. But it was clear in the discussion which followed that many German-speaking men of science were not yet converted to his ideas. Doubts were expressed on the validity of his views on the equality of inertial and gravitational mass, on the velocity of propagation of gravitational processes, on the possibility of ever being able to detect the deflexion of light rays in a gravitational field or the predicted red-shift of spectral lines in such a field. The over-riding impression left on my mind was that the older generation was more sceptical than the younger and, indeed, several of these young men, then in their

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