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GREATEST SCIENTIST OF THE AGE

A simple statement of Einstein's revolutionary contribution to science and its relation to the Newtonian view of the world that it supplanted

By John Stachel

THE advance if science is steady but slow, in the main. A new fact is added to the store; a new result is obtained from an old theory; some existing hypothesis is modified. New bricks are constantly added on the foundation of the old. Yet sooner or later a time comes when all progress seems to be coming to a halt. The new bricks will not fit. The old ones start to crumble. It becomes more and more apparent that the old structure cannot be patched up. The basis must be rebuilt. Science is on the eve of a revolution. Such was the state of biology before Darwin; such was the stage of political economy before Marx; such was the state of psychology before Pavlov. Of course, science would have moved forward without these great intellects. The facts, sooner or later, will force our ideas into conformity. But a mind of genius, grasping the essence of the crisis, can move forward firmly to overcome it, to remold the basic concepts of science, avoiding years of groping and false starts. Thus others, following this lead, can begin to work out all the detailed consequences of the new outlook, instead, perhaps, of spending a lifetime wandering in the wilderness of knowledge.

Albert Einstein had such a mind and such was the contribution he made toward resolving one of the crises in physics at the turn of our century. Physics is the science that studies the most general properties of matter. It forms the basis for the great technological advances of our times and its basic concepts are fundamental to all science and indeed to the world outlook of all civilized peoples. And it was to the study of these basic concepts that Einstein devoted his whole life with an intensity that he well characterized in speaking of the work of another physicist, Max Planck: "The state of mind which enables a man to do work of this kind is akin to that of the religious worshiper or the lover; the daily effort comes from no deliberate intention or program, but straight from the heart." The sense of Olympian calm and aloofness from human relationships that even his best friends have noted is explained by the intensity of his relationship to the chosen objects of his devotion, the laws of nature, more real and compelling to him than anything else in the world.

It was to the development of the theory of relativity, of course, that Einstein devoted the bulk of his enormous powers and it is with this theory that his name will be associated through the ages. Let us try to see what the essence of this theory is. To do this, we shall have to look at the theory it superseded, the Newtonian theory.

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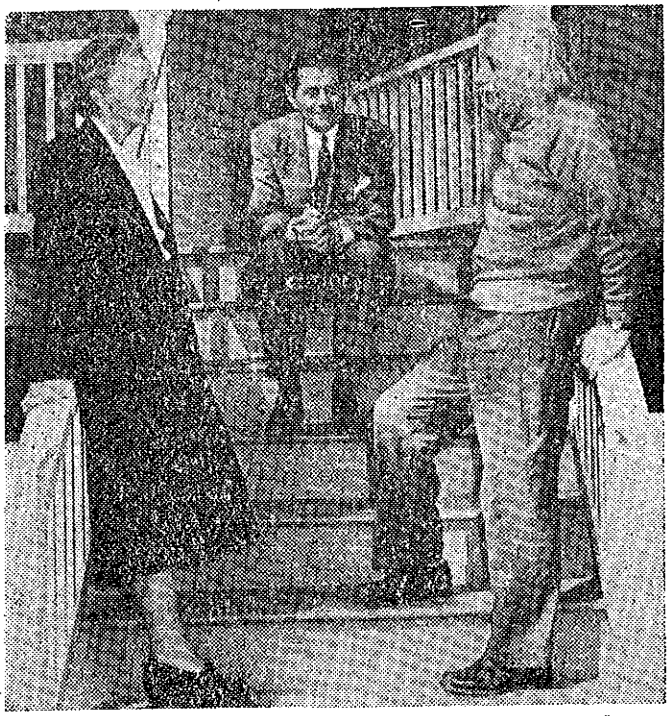
Newtonian Theory in Trouble

Sir Isaac Newton, the great English physicist of the seventeenth century, formulated the first mathematically precise theory of physics. He took over and refined a number of concepts from every-day experience to serve as the basis of physical theory, in particular the concepts of space, time and matter. He viewed the world as made up of bits of matter moving about in space as time goes on. Each of the three elements—time, space and matter—was taken to be completely independent of the other two, able to exist without them. Each was absolute in that its essential nature was not modified by the other two.

But, of course, in the real world they do interact, so Newton was forced to introduce two new concepts, also independent of each other, to explain this interaction. He assumed that there are forces which bodies exert on each other across space; and that there are laws of motion which tell us how matter moves under the influence of these forces. As an example we may take Newton's greatest scientific success. He was able, by assuming the existence of a universal force of gravity, attracting every object in the universe to every other object, and using his famous laws of motion, to explain why the planets move around the sun in oval paths. On the basis of these five independent and absolute concepts—time, space and matter, related through forces and laws of motion, physics was able to move from success to success for 200 years after Newton.

Now all of these concepts seem quite reasonable to us at first sight. They were originally drawn from the every-day level of experience, and they have been filtering through from physics into general knowledge for 200 years. They certainly express some measure of truth about the world. But if we look at matters a little more closely, we may begin to wonder whether these concepts can be taken just as Newton did. Can they really be so independent of each other? Can matter really exist outside of space and time? And are space and time uninfluenced by the matter they contain? Just what is a force? How can the sun, 92 million miles away, exert a pull on the earth? Many of these ques-



Madame Irene Joliot-Curie (left), noted French nuclear physicist, visited with Einstein in 1948 while she toured the country on behalf of the Joint Anti-Fascist Refugee Committee. In the center is Dr. Edward E. Barsky, chairman of the Committee.

tions occurred to scientists and philosophers from time to time. Marx and Engels, in particular, on the basis of their general philosophical outlook, saw that Newton's world-view could not be more than a first approximation to the truth.

Einstein Develops Relativity

But it was not until science itself began to run into difficulties with the Newtonian picture that the stage was set for a new scientific advance. It was the accumulation of these problems that led Einstein, with his characteristic ability to penetrate to the essence of a scientific problem, to sense the need for a re-examination of the accepted fundamental concepts underlying all of physics. What Einstein did in the years between his first paper on relativity in 1905 and his death was to remove, one after another, the barriers that separated the concepts of time, space and matter.

By showing the nature of the deep inner interrelation between them, he was able to dispense with the idea of a separate force of gravity and to show how the nature of gravity flowed from the nature of matter. He was also able to show that the laws of motion of material bodies flowed from the very nature of their relationship with time and space. Thus the five absolute concepts of Newton were stripped of their independence and fused into a whole.

Encouraged by his elimination of the mysterious "force" of gravity, Einstein spent the major part of his time, from 1916 on, in trying to eliminate another great force that had been assumed: the electromagnetic force, responsible for all electrical and magnetic effects. Here, too, he wanted to show that this apparent force was the result of an interaction between matter, space and time. This was his Unified Field theory, which was left still unfinished at his death. But enough had been accomplished to encourage others to take up the task of explaining the nature of the remaining forces known to science.

It Makes a Difference

We may ask: just what difference does it make whether we accept the new concepts or the old? After all, Newton's physics is close enough to the truth to enable us to build all our cars and bridges. Are we just playing around with fancy words? The answer is that the change is vital enough to justify calling it a scientific revolution. Let me give three reasons. In the first place, the newer concepts of matter form the basis for a deeper understanding of the world about us. For that reason, they are bound slowly to penetrate into the minds of millions of people, just as Newton's did, and give their outlook a surer scientific footing. And such changes are found to affect one's outlook on many other things in life as well. Our great-grandchildren may get their Einstein in grade school.

In the second place, no such radical change could take place in the foundation of physics without having many important practical consequences. Einstein's theory has explained hitherto unexplained facts. It has led to the discovery of new facts and laws and shown many old ones in a new light. The most dramatic and useful of these results, was his discovery that energy and mass, once thought to be completely separate, could be converted into each other. They are related by the formula $E=mc^2$. This meant that huge amounts of energy could be liberated by the conversion of small amounts of mass, and today we are on the threshold of an energy revolution based on this discovery, as well as faced by the challenge of the A- and H-bombs it made possible.

Lastly, the theory of relativity, by refining and reformulating certain basic concepts of physics and discarding others, has started one of the periodic house-cleanings without which science cannot advance. All other theories of physics, and indeed all the sciences which use physics, must now undergo a slow process of re-examination and reappraisal in the light of the newer concepts. This shakeup is bound to have long-range and unpredictable consequences. And this shake-up, we venture to guess, is still in its opening stages, particularly since the theory of relativity itself is subject to much further development. If it took 200 years to clarify Newton's theory and its implications, we may be sure that many years will be needed to elaborate Einstein's theories.

Other Contributions

Even a brief discussion of Einstein's contribution to science must mention a few of his many other contributions, which would have brought fame to him even without his work on relativity. Most noteworthy was his active role in the other great scientific revolution of our time, the study of the world of the very small—the atom and its components. Here too, as in the region of high speeds and vast spaces that the theory of relativity treats, the laws of the ordinary scale of matter we are familiar with break down.

Waves, such as light, behave as if composed of particles; and particles, such as the atom or the electron, behave as if they were waves. In each case, although Einstein was not the first to start investigating these strange properties of matter, he was the first one to see the full implications of the work of others; and by his own contributions he materially hastened the development of the quantum theory, as the new conception of the atomic world is called.

The paradoxical nature of this theory, which is not at present capable of fully describing processes whose probable end results it can treat successfully, has led many scientists to doubt the possibility of working out a complete objective description of nature. There is much loose talk about science having eliminated matter, the reign of change in nature, the end of causality, etc. Einstein has always stood firm against these skeptical misinterpretations of science, interpretations not without value to those forces that want to call the efficacy of science into question.

He has insisted: "I still believe in the possibility of a model of reality—that is to say, of a theory which represents things themselves and not merely the probability of their occurrence." His stand that the atom can be understood on a casual basis, shared with leading Soviet and other progressive scientists, has influenced many others in recent years. A restudy of the interpretation of quantum theory has begun in many places.

Einstein's work in statistical mechanics, the theory of Brownian motion, in spinor theory and many other fields have been noteworthy. He was also a great popularizer of science, having written several books and literally hundreds of articles with the general public in mind. These works, we might add, do not attempt to talk down to the reader, but are based on the realization that the broad implications of scientific theory are of vital concern to the public at large.

And now he is gone, leaving behind his rich heritage of methods, ideas and still unsolved problems, a heritage that will keep scientists busy for many years. Whatever the ultimate fate of Einstein's theories (and they will undoubtedly undergo many changes and revisions and in turn give way to a higher synthesis, a closer approximation to the inexhaustible richness of truth, just as Newton's theories did), Einstein's contribution constitutes a landmark in the development of science. Humanity, too, is richer by another life that has proved the greatness of the human creative spirit. Such a man can be truly measured only by the centuries.

"EINSTEIN HAD NO FEAR OF DEATH"

By Dr. Leopold Infeld

The following statement was made after the death of Einstein by Professor Leopold Infeld, who collaborated in a number of works with Einstein at the latter's invitation. Professor Infeld spent some years working with Einstein at the Institute for Advanced Studies at Princeton. Dr. Infeld is at present professor of physics at Warsaw University, a vice president of the World Peace Council and a member of the presidium of the Polish Defenders of Peace.—Eds.

DURING my sojourn at Princeton, just about 20 years ago, Einstein said to me one day: "If I knew I was going to die in three hours, it would affect me very little. First of all, I would put all my notes in order and then I would lie down quietly to await death."

Einstein had no fear of death. He even laughed at it. Seven years ago, when I visited him at the hospital where he had to undergo an operation and I inquired about his illness, he replied, "The doctors themselves don't know anything about it." Then, breaking into a burst of laughter, he added, "They'll find out at the autopsy."

Death counted for little with Einstein but his passing matters a great deal to all humanity. His death was a blow to all those—and they were very many—who knew and loved him, all those who admired his marvelous intelligence.

His death cruelly affects all physicists. He who was probably the greatest physicist of all time—with Newton—has left us. His going just as cruelly hits all those who neither knew nor understood his theory, but for whom the name of Einstein was the symbol of a disinterested fight for justice, progress and peace, those for whom the face and words of the great man represented a source of hope.

In contemplating his inspired features on photographs, in reading his declarations, so courageous and full of dignity, all brave people will think: "There was a man of irreproachable conscience of whom the human race can be proud."

A great light has been extinguished. His goodness and generosity will remain forever engraved on our memories. And legends will form about this man, who was the greatest scientist of our age and also a great man.