PHYSICS

Relativity Theory Framework Strengthened by Einstein

Eliminates Use of Electromagnetic Theory In the Deriving of Relationship Between Mass and Energy

LIKE a careful contractor who removes a stone of doubtful strength from the foundations of a building, Prof. Albert Einstein strengthened the basic foundations of his famous theory of special relativity in his address before a select group of 450 mathematicians and physicists attending the meetings of the American Association for the Advancement of Science.

Prof. Einstein's purpose in presenting his paper on "An Elementary Proof Concerning the Equivalence of Mass and Energy" was to put on firmer ground the use of the equation $E=MC^2$ in experiments dealing with atomic processes such as artificial radioactivity.

The now-famous equation was derived without the use of concepts dealing with the nature of the electrical forces within the atom where scientists have yet to make experimental measures. Assumptions on these electromagnetic forces were part of Einstein's first derivation of the equation.

Quietly, and carefully, Prof. Einstein took his audience back to 1905 when his famous paper on the special theory of relativity appeared. At that time, he explained, it seemed necessary to use a concept that an electromagnetic field energy may be localized.

Operates Radio Sets

Electromagnetic field may sound complicated but it is the varying electromagnetic field energy sent out by a broadcasting station which makes the radio sets in the homes of America operate.

The concept that the energy in a magnetic field might be localized in various points in space, Prof. Einstein said, has always been in a state of doubt amongst scientists. One group felt that the idea was sound; the other believed it was not, but neither could prove its point. It is this unprovable doubtfulness which Prof. Einstein feels is a weak link in his 1905 paper on relativity.

In his address Prof. Einstein gave a simple proof of the way energy is related to mass by the relation, energy equals mass times the square of the velocity of light, and he did it without using the doubtful electromagnetic field energy localization of his 1905 report. His simple proof depended only on the conservation of momentum when two similar bodies collide in the inelastic and elastic impact, and upon the famous method of transforming coordinates in space developed by Lorentz.

For Future Textbooks

Prof. Einstein's proof may be of historic interest, for physics textbooks of the future may contain it instead of the present more complicated one. Such a situation has occurred before in other fields of physics. College students today often memorize a simple proof of some important theory developed years after the pioneer roundabout concepts. Such was the case for the famous equations of Clerk Maxwell and such may be the case for the Einstein theory of relativity.

Following Prof. Einstein's address Dr. Karl K. Darrow, well-known for his interpretations of the discoveries in physics for physicists, wrote the following summary interpreting the new proof of the mass-energy equivalence theorem:

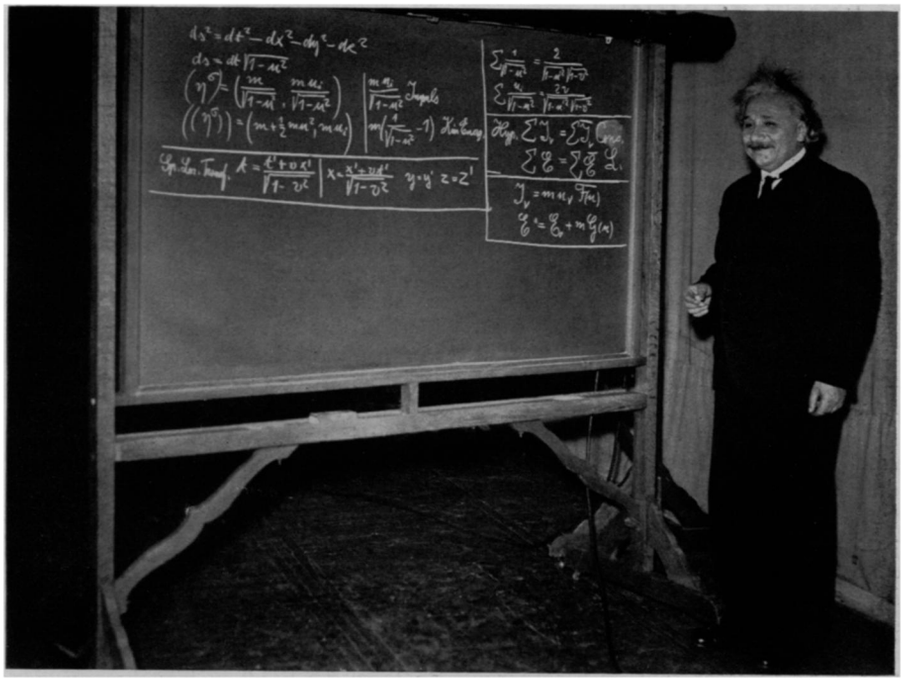
By DR. KARL K. DARROW, Associate Editor, Physical Review and Physicist, Bell Telephone Laboratories

Dr. Einstein presented his new proof of the equality of mass and energy at this time because of the immediate usefulness of the relationship to physicists and chemists. Although Dr. Einstein believes there is no prospect of obtaining energy from the atom's mass for any practical purpose, some of the newly-discovered phenomena of transmutation have shown that mass and energy are interconvertible.

For example, when a transmutation is effected by projecting a hydrogen nucleus into a lithium nucleus, the result is the creation of two helium nuclei which fly away with an enormous kinetic energy—17,000,000 electron-volts.

To give an idea of how vast this energy really is on an atomic scale, it may be remarked that when a cannon ball or an airplane is moving at the highest attainable speed its kinetic energy *per atom* amounts to less than one electron-volt.

Were we to disregard this kinetic



MAKING IT CLEAR

energy we should be forced to give up the principle of the conservation of mass, since the masses of two helium nuclei at rest add up to a sum definitely less than the masses of the original nuclei of the lithium and the hydrogen; but it turns out that the mass of that kinetic energy is of just the right amount to annul the discrepancy and make perfect the balances of the masses before and after the collision.

There are other such cases and all prove that Einstein's theorem of the equivalence of mass and energy is valid, and valid even for those nuclear phenomena for which we have no certainty that the ordinary laws of electricity are true.

Dr. Einstein therefore wished to make a derivation of his famous theorem not depending in any way upon those laws as did some of the earlier derivations. His present proof has this feature. Nothing is postulated except some of the fundamental assumptions which were made about moving particles in the earliest theories of Lorentz and Einstein.

To be precise, he imagines two particles colliding, and he shows from these assumptions that if their mass changes at the collision their energy must suffer a counter-balancing change.

Physicists will welcome this new demonstration of a principle which has suddenly assumed so great an importance in their field.

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PHYSICS

Here is Einstein's Theory In Words of One Syllable

About ten years ago, Dr. Edwin E. Slosson, late director of Science Service, wrote upon request what he termed "The Einstein Primer," explaining the theory of relativity in words of one syllable. The following article offers in one-syllable words the background of Einstein's recent talk on "A Simple Proof of the Equivalence of Mass and Energy." Only three words in this article contain more than one syllable: Einstein, energy, and electricity or electric.

By ROBERT D. POTTER

IT can be said that the weight of a thing is its mass times the pull of the earth on it. Thus its weight is fixed by the place where it rests on earth. But mass, too, is shown by tests to change with speed. There are, then, two kinds of mass; a rest mass and a speed mass.

How much mass may change with speed is shown in tests where a charge of electricity is made to go just a bit less than the speed of light. Then its mass may be twice as much as when at rest.

Think of it this way. A shell comes from a gun. As it speeds in the air it drags some of the air with it. The whole mass that moves in the air is part shell and part dragged air. The sum of the shell mass and the air mass it drags goes up as the speed of the shell.

Einstein shows that a group of things that has a mass of sum M has energy E, which is the same as M times the square of the speed of light. This fact is true both when the mass is at rest or when it moves. Thus a watch wound up weighs more than one not wound. And a fly wheel that moves weighs more than one at rest.

Only hard tests show this gain of mass; for the gain must be cut by the square of the speed of light which is very large. A big ship that moves at sea gains in weight just about 1,000,000 part of an ounce by its speed.

Sir James Jeans says that all the energy a man puts in, in a life time of work, weighs just one 60,000th part of an ounce. Thus it can be seen why it would be of such use to get the energy out of just one ounce of gold, or air and such things. It would be worth as much as six times ten, times ten, times ten, times ten of men.

When one gram of the most light kind of gas is made to change to the kind of gas which lifts air ships there is a loss of .008 grams of mass. While the loss of mass is small, the gain in energy is great. W. F. G. Swann says the energy is as much as that which would heat rain in a tank ten feet deep and eight times ten feet wide from ice to steam.

One way to get this energy out would be to break up small bits of mass. Man can do this now when he makes bits of mass with electric charge on them hit hard on bits that are not the same. Such hits may cause rays that are not seen but which go right through things with great energy. Tests show, too, that energy may turn to mass. Thus some of the new bits of mass just found in the last two years may be made when hard rays that are not seen but come from the sky hit things in tests. Jeans says that when bits of mass join far out in space they may cause the known hard rays.

Einstein told how to prove on paper in a way not too hard how mass is bound up with energy. That is why men went to hear him.

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PHYSICS

Einstein Believes in Orderly Certain World

PROF. Albert Einstein believes in an orderly world in which you can predict with certainty what is going to happen, despite the fact that his theories have seemed to undermine such ideas.

He holds the door open to an infinite universe, although his relativity has been associated with a finite universe.

And he "feels absolutely sure, nearly sure, that it will not be possible to convert matter into energy for practical purposes," although his famous equations of 1905 prove conclusively that matter and energy are interchangeable.

Trying to get energy from the atom is not practical because you have to use so much energy to do it. It is similar, Prof. Einstein said, in an interview at Pittsburgh, "to shooting birds in the dark in a country where there are only a few birds."

Uncertainty now seems to rule in the physical world, but Prof. Einstein believes that eventually a new kind of certainty will hold sway. Prof. W. Heisenberg has shown, Prof. Einstein recalled, that it is impossible to observe a situation without influencing it in a way unknown to us. This makes it impossible to know that initial state and so also the final state of a situation.

It is impossible to verify finally the law of causality. This has caused most scientists to believe in a universe ruled by the statistics of probability, but Prof. Einstein has a feeling that the final form of our physical law will be deterministic. This nobody can know.

Prof. Einstein says how we view the world is a matter of taste. Science is not yet sure whether the universe is finite or whether it goes on in space forever. Prof. Einstein explained that the "curvature of space may be positive,