Classics of Science: Effects of Relativity

Physics

Lorentz was one of the small group of mathematical physicists whose work led up to the Einstein theory. He, with Fitzgerald, in 1892 interpreted the negative result of the famous Michaelson-Morley experiment by the hypothesis that the apparatus contracts in the direction of the earth's motion. Lorentz' biography appears on page 146 of this issue of the SCIENCE NEWS-LETTER. While most of us will not be able to understand in all its details the following quotation, it will give some idea of the fields in which Lorentz did his work.

PROBLEMS OF MODERN PHYSICS, A Course of lectures Delivered in the California Institute of Technology, by H. A. Lorentz, Professor in the University of Leiden, edited by H. Bateman, Professor in the California Institute of Technology. Boston, 1927.

The Rotation of the Earth

This rotation, which has been established by Foucault's pendulum experiment and by the phenomena of falling bodies, can also conceivably be proved by electromagnetic or optical phenomena. Diurnal aberration has not been observed with certainty, but an interference experiment has been planned by Professor Michelson in which light is to be sent by means of reflecting mirrors round a triangle in two opposite directions, in order to see whether any difference in the time of propagation is produced by the earth's rotation. (Since this was written, the experiment has been performed with the expected result.)

Consider an ideal experiment in which electric waves travel around two parallel wires, as in Lecher's system, except that the wires are supposed to be placed round the earth's equator, each forming a closed circle. The theory of relativity, as well as the old theory of a stationary ether, would require that the velocities of propagation in the two directions relative to the earth be unequal. There will then be standing waves whose nodes and loops move round the earth, making a complete circuit in a sidereal day. The earth may be said to rotate relative to these nodes and loops. (In this discussion we need not speak of the gravitational field of the earth; the phenomena would be the same if the earth exerted no gravitation at all.)

Now choose a system of coördinates. We can do this in two ways:

1. So that the loops and nodes are stationary; that is, so that the velocity of electric waves is the same in both directions. In this system we have the normal values of the potentials g_{ab}, and the earth appears to rotate.

2. So that the axes are fixed to the earth. We now have different values of the g_{ab}'s that can be found by means of the transformation formulæ. The new g_{ab}'s also occur in the equations of electromagnetism, and these show that the nodes and loops are rotating and that the velocities in the two directions are unequal.

Thus when we are asked *with respect to what* the earth rotates, we may say that it is rotating in a system of coördinates in which the g_{ab}'s have their normal values. Foucault's experiment leads to the same conclusion.

But we may wish to think of the earth's motion as motion relative to something that is more substantial than a mere system of axes of coördinates. Here there are two alternative views.

Physicists of former days would say that the nodes and loops have their seat in the ether—that the earth rotates relative to this medium and that the g_{ab}'s have their normal values in a system of axes that is at rest in the ether. We have no longer to account for these normal values, the properties (if we may call them so) of the ether being responsible for them.

On the other hand, according to Einstein there is no such thing as the ether of which we have just spoken. If there is some medium, it has not sufficient substantiability to enable us to use it as a framework of reference with respect to which the position of bodies can be determined. Einstein thinks that in our experiment the nodes and loops are fixed in some way or other relative to the fixed stars, seen or pehaps unseen. This conception can be admitted because the stars are really seen rotating around the earth. Therefore we can admit that the nodes and loops are kept in their places by them, so that it is relative to them that the earth rotates.

Of course this implies that there is some kind of connection, or link, between the stars and the earth. Indeed, if there is nothing of the kind between them, the conception of relative motion is wholly clear. We cannot, without further explanation, even draw a straight line toward some star. Now, according to Einstein, the system of coördinates in which the g_{ab}'s have their normal values is not determined by the fixed stars by some mysterious influence but (*Turn the page*)

Short-Wave Tube

Physics

A vacuum tube with a power of 15,000 watts, sending out radio waves of only six meters length, that can light electric lamps without wires or socket, produce a warmth in nearby spectators reminiscent of prohibited stimulants, and cook sausage in a glass tube without fire, is one of the latest radio wonders. It has just been demonstrated at the General Electric Company's research laboratory at Schenectady.

The new tube, known as the ZT-6, looks harmless enough. It is about five inches in diameter, and two feet long, set in a wooden cage and surrounded by a network of wires, condensers and meters. With its great power of 15 kilowatts, it is at least fifty times as powerful as any short-wave tube previously constructed. Through a coupling system it is connected to a copper bar about three meters, or ten feet, long, which acts as the tuned aerial circuit, radiating the full 15 kilowatts into space.

When an ordinary electric lamp is touched to the copper bar, it lights up brilliantlty. A loose copper rod, lying on the floor, is picked up, and, though cold, it blisters the hand. When a person approaches the apparatus, he first feels a warm glow, then pain in the limbs and joints. Artificial fever, as much as 100 degrees Fahrenheit, is induced after standing close to it for 15 minutes.

This may indicate one of the future applications of the tube, says Dr. W. R. Whitney, director of the laboratory. "If we had a perfectly harmless method for warming the blood it might have (*Turn the page*)

Physics of the Bowling Ball

Physics

Bowling enthusiasts will now have available a scientific study of their favorite pastime. At a meeting of the American Physical Society recently, Dr. L. W. Taylor, of Oberlin College, told of apparatus that he has developed to study the motion of the ball in a bowling alley. A recording device registers to the hundredth of a second the passage of the ball at half meter (about 20 inch) intervals. Instead of rolling the ball by hand, a catapult is used, so that the force used can accurately be controlled. Studies already made with the device indicate that the accepted theories of the ball's motion are not quite correct, but that the friction seems to vary with the ball's speed.

Tube—*Continued*

value," he stated, "because fevers are sometimes artificially produced to start convalescence, and it may well be, as asserted, that raised blood temperature, or fever, is one of nature's factors in the recovery from infectious diseases."

Another feat of the apparatus, which also involved the heating of animal tissue without fire, was the cooking of a sausage in a glass tube, suspended from a wire some distance from the transmitting aerial. An apple was placed on the end of this receiving aerial and in a few minutes it was thoroughly baked to the core.

One of the most spectacular "stunts" performed was the imitation of the famous but seldom observed "ball of fire" reputed to accompany tropical thunder-storms. When the end of the radiating aerial was touched with a metal tipped pole, a greenish white arc arose to a height of a foot or more. This arc remained, even after the pole was removed, like a plume of fire, sputtering and sending out molten copper in all directions until it was blown out. As many as three of these standing arcs, each without any visible return circuit, were established along the bar at once.

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Relativity—*Continued*

by the gravitational field which they produce. In his opinion, even the normal values of the g_{ab}'s constitute a gravitational field due to the stars; and if the stars were not there, we should not have these normal values. This is connected with Einstein's idea that the inertia of a body must be considered as relative to something else; that is, to some other body. As a measure of inertia we can take momentum. The first component of the momentum is given approximately by $-mg_{11}x_1$; and when the g_{ab}'s have their nominal values, this becomes mx_1. Einstein thinks that if the stars were not there, we ought to have $g_{11} = 0$, so that, even if the body were moving with respect to certain axes of coordinates, it would have no momentum.

I have now partially, though rather imperfectly, indicated the line of thought which led Einstein to his field equations in their later form. I cannot enter into the solutions which they admit; it will be sufficient to say that he considers three-dimensional space as finite. The time coordinate x_4 can have all values ranging from $-\infty$ to $+\infty$, but the space coordinates are limited, so that the extension that corresponds to them is in three dimensions what the circumference of a circle is in one and the surface of a sphere in two. Like these latter extensions it has a definite radius R (immensely greater than any distance with which we are familiar), and the constant χ is connected with this radius. Now, on account of the term with χ in the equation,

$$G_{ab} - y g_{ab} = -k(T_{ab} - \tfrac{1}{2} g_{ab} T),$$

the stars really determine the g_{ab}'s.

If we pass from the system of coordinates in which we have the normal g_{ab}'s to another fixed to the earth, we have different g_{ab}'s; these new values are again due to the stars, which are rotating in the new scheme and therefore produce a different gravitational field.

In performing the necessary calculation Einstein supposes the mass of the stars to be uniformly distributed, but we shall not speak of this.

The Time Variable

Let us finally revert for a few minutes to the special theory of relativity and to the transformation used in it, in which time also is involved,

$$x' = x, \quad y' = y, \quad z' = az - bct,$$

$$t' = at - \frac{b}{c} z.$$

You will remember our two observers A and B, using the different times t and t', and each able to describe physical phenomena in exactly the same way, though what is simultaneous for one is not simultaneous for the other. The theory of relativity emphasizes the fact that one of these is exactly as good as the other. A physicist of the old school says, "I prefer the time that is measured by a clock that is stationary in the ether, and I consider this as the true time, though I admit that I cannot make out which of the two times is the right one, that of A or that of B." The relativist, however, maintains that there cannot be the least question of one time being better than the other.

Of course his is a subject that we might discuss for a long time. Let me say only this: All our theories help us to form pictures, or images, of the world around us, and we try to do this in such a way that the phenomena may be coordinated as well as possible, and that we may see clearly the way in which they are connected. Now in forming these images we can use the notions of space and time that have always been familiar to us, and which I, for my part, consider as perfectly clear and, moreover, as distinct from one another. My notion of time is so definite that I clearly distinguish in my picture what is simultaneous and what is not.

The fact that physical phenomena can just as well be described in terms of z and t as in terms of z' and t' simply means that I can form my picture in two different ways; namely, by taking t or t' for my time. The principle of relativity teaches us that one of the two modes of description is just as good as the other. There is nothing very strange or inconceivable in this.

As to the ether (to return to it once more), though the conception of it has certain advantages, it must be admitted that if Einstein had maintained it he certainly would not have given us his theory, and so we are very grateful to him for not having gone along the old-fashioned roads.

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Turning muskrat skins into fur requires more than 70 different processes.

Groves of cork trees are an important commercial French project in Algeria.

Carrier pigeons have been known to find their way home from a distance of 600 miles.

The first census of the Turkish people, recently taken, gave a figure of 14 million.