urement left in it, for he described it as flowing "equably." This is reasonable on Newton's part, for the residue is actually inconceivable unless some measurement is left in it. For Bergson's duration is inconceivable and yet it is what is left after the attempted subtraction. To give it a plausible but pseudo conceivability he has to give intuition a new meaning as an impossible substitute for intelligence, designed for the very purpose of apprehending a duration stripped of anything that can be called a measurement of it. Whatever this impossible duration of Bergson's may be it is the stuff of which the world is made before measurement has ever touched it, if the world were ever in such a condition. This inconceivable substance of all things has come from just that attempt to abstract measurements from what they measure. The inconceivability is good evidence for the proposition that measurement can not be even abstracted from what it measures, say nothing about separating the two in any concrete sense. We find then a more intimate union of the measured and the measurements. Thus if we go back in the process of evolution to this more primitive quality, duration, we find that it is strikingly inseparable and ever inconceivable apart from its measurement.

Thus we may be permitted to add to the better-grounded argument given above this speculative possibility pointing to the resolution of the dualism of Eddington of a metrical and a non-metrical, into a monism whose unit is a measured quality where even the grammatical and logical analysis into substantive and adjective breaks down more completely than before.

If there is thus a primitive measured quality time, duration, already measured in the most primitive form of it, it must get additional measurements through the cyclic process of its evolution, coming to be measured into those periodicities that make color and sound of it.

This speculative excursion is not needed for the argument of this paper, but it is suggested by the main discussion and it points to the intimate union of the measured and the measurements that measure it, of the qualitative and the quantitative, of the so-called mental and the so-called material.

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THE THEORY OF RELATIVITY: FOR WHAT IS IT A DISGUISE?[1]

IT is generally assumed that Einstein, in propounding the theory of relativity, has discovered something hitherto unsuspected about time and space, namely, that they are functions of the rela-

[1] Read at the meeting of the American Philosophical Association, New York, December, 1929.

tive motion of material bodies, and hence share the property of relativity which motion itself possesses. But if we examine this assumption in the light of Einstein's writings we find it to be a mistaken one, since the kind of time and space referred to by Einstein are by him *defined* to have this property, not *discovered* to have it. In short, the "discovery" is expressible in the proposition "Relative time and space are relative," a truism embodying as much discovery as the proposition that right-angled triangles are right-angled. Both of these propositions are true, but neither can be the expression of a theory, certainly not of a debatable one.

The fact is that Einstein has appealed to no new physical cause in his successful prediction of physical phenomena. He has simply substituted new definitions of "time" and "length" for the Newtonian ones. And how a mere change in the definitions of words, a mere juggling of units of measurement, can afford predicting power, is the mystery which besets modern physics and nonpluses modern physicists. As Bridgman expresses it: "Three definite conclusions about the physical universe have been taken out of the hat by the conjuror Einstein, . . . and the problem for us as physicists is to discover by what process these results were obtained."[2]

In this paper I shall venture to advance an hypothesis of the nature of this seemingly magical process, and shall therefore at the outset direct attention to the expedient by which Einstein obtained his new definitions. The history of physics tells us what it was.

A certain experiment designed to discover the earth's motion relative to the ether, involving the observation of interference fringes in light, had been proposed. A certain formula expressing the shift of these fringes to be expected assuming a given velocity (v) of the earth, had been worked out. A certain interferometer sensitive enough to reveal the shift assuming (v) to be at least as high as the known velocity of the earth in its orbit, had been devised. The experiment was tried by Michelson and Morley and came out negative. The expected shift was not observed. And physics was thus confronted with the question, "Why?"

Einstein undertook to answer this question, and in order to do so, he first examined the formula predicting the shift, which contained, among others, the fundamental magnitudes, or "dimensions," time and length. He then asked himself this question: "By what change in the definitions of time and length can I make this formula come out negative for all velocities of the earth and other bodies?" And proceeding to make the necessary calculations, he

[2] *The Logic of Modern Physics,* P. W. Bridgman, p. 171.

formulated the so-called "Lorentz transformation"[3] expressing his new definitions of time and length (interval). This transformation embodies the special theory of relativity, and the general theory is a modification of the special.

Now the process used by Einstein is a special case of a very general one, which may be called the process of discovering "dimensional explanations," so called because it consists in redefining one or more of the fundamental dimensions, time, length, and mass, of which other physical magnitudes, such as velocity, acceleration, etc., are functions. It may be briefly described as a process for transferring to one or more of these dimensions, the variability of physical causes in such a manner that the variability of the cause is expressed in the formula by a variability (relativity) of the appropriate unit or units, and hence can be attributed to that relativity. Instead of leaving the units constant and correcting for the varying cause, the cause is assumed constant, and the correction made by varying the units,—both processes giving the same result. Given the requisite mathematical ability, as many kinds of relative time, length, mass, space, velocity, etc., as we please may be "discovered," and they will all have the magical predicting power which the kinds devised by Einstein are found to have.

For instance, it is possible to retain the assumption prevailing previous to Römer that the velocity of light is infinite, and predict all effects on light signals actually due to the finite velocity of light by redefining time according to the following "transformation":

$$T' = T + \frac{d}{186{,}000} \tag{1}$$

where T' is the time in seconds on the observed system, T the time on the observing system, and d the distance in miles between the systems, thus discovering a relativity of time with distance. And it is also possible to adopt the assumption that the earth is a perfect rotationless sphere, and predict all effects on the rate of pendulum swing at different latitudes actually due to the rotation and oblateness of the earth, by redefining time according to the following "transformation":

$$T_l = T_0 \frac{1}{\sqrt{1 - .0025 \cos 2L}} \tag{2}$$

where T_0 is the time at latitude 45°, L, the latitude, and T_l the time at latitude L; thus discovering a relativity of time with latitude.

Indeed, a dimensional explanation is characterized by the fact that it is not an alternative to, but a disguise for, a non-dimensional one; a non-dimensional explanation being one which retains the

[3] Lorentz had previously arrived at this transformation on the basis of Maxwell's equations and the assumption of a stationary ether.

Newtonian definitions of dimensions, and attributes effects to physical causes instead of units of measurement. Thus the predicting power of a dimensional explanation is due exclusively to the fact that it constitutes a disguise for a non-dimensional explanation. And this brings us back to the hypothesis I am venturing to advance in this paper, which is that the equations of relativity possess predicting power because they embody definitions which are disguises for a non-dimensional explanation of some kind. In short, I shall assume that if some actual cause in nature corresponding non-dimensionally to his new definitions did not exist, Einstein's equations would have no predicting or explaining power. Our problem then can be formulated thus: Given the dimensional explanation provided by Einstein: *To find* the corresponding non-dimensional explanation.

This is a problem to which a possible solution will here be suggested. In order to render it generally intelligible, I shall first define a term necessary to its expression:

The phenomenon, common to sound and light waves alike, known as a Doppler-effect, is familiar to physicists. It is an effect on the waves caused by the movement of their source, a shortening of wave-length in the direction of motion and a lengthening in the opposite direction. It is the Doppler-effect which causes the pitch of a locomotive-bell to fall as it passes a person standing on the station platform, and it is the same effect that enables astronomers to measure the relative velocity in the line of sight of the earth and the stars. This effect is registered in the spectroscope as a displacement of spectral lines, a displacement toward the violet end of the spectrum when the star is approaching and toward the red end when it is receding. Now this change of wave-length is always associated with changes of momentum and energy in the radiation subject to it, changes inversely proportional to the square of the wave-length. To these associated effects may be given the name of Doppler-displacements.

Let us next consider the theory of space assumed by the Newtonians and Einsteinians, for despite Einstein's redefinition of "space," the two schools agree about space in one important particular. They agree that it is a static space, except for the starlight which traverses it. Indeed, this is the general assumption among physicists. The Newtonians, however, usually assume that space is filled with a static ether or medium which conveys the light, whereas the Einsteinians usually assume there is no ether at all.

The theory which I shall venture to propose resembles the Newtonian more than the Einsteinian assumption. It assumes that there is an ether, but that it is a dynamic instead of a static one. The basic assumption of the theory is that space is filled with radiation of super-frequency and hence super-penetration, moving in all directions, essentially as star-light does, and having the same velocity—186,000 miles a second; and that matter (as well as light) is a modification of this field of radiation which transforms a minute fraction thereof into a form less absorbed by matter than the normal. It is further assumed that all material change of motion is due to unbalanced radiation pressure in this field or some modification of it, a rather plausible assumption, since it has been proved in the laboratory that radiation exerts pressure on bodies which absorb or reflect it.

The theory thus briefly and incompletely expressed, I shall call the radiation theory. And I shall assume that the relativity definitions of time and space are disguises for, and mathematical equivalents of, the Doppler-displacements in the radiation postulated by the radiation theory. In short, it is these Doppler-displacements which provide the non-dimensional counterpart of the Einsteinian dimensional explanations, and it is because they are causes actually operating in the universe that the relativity equations have predicting power.

Now it is obvious that in a brief paper such as this, it would be impossible to go into details about the predictions of the radiation theory, and the comparison thereof with facts. Suffice it to say that many predictions are forthcoming, relating to both relativity and non-relativity phenomena, and that their accordance with the facts is, on the whole, confirmatory of the theory. In the present condensation only a summary of the more suggestive verifications can be given, as follows:

(1) The radiation theory predicts that relativity effects will be a maximum in directions coinciding with, or opposite to, that of the motion of bodies, because Doppler-displacements are.

According to the Lorentz transformation, the effects are a maximum in these two directions.

(2) The radiation theory predicts that relativity effects will be zero in directions transverse to the direction of motion of bodies, because Doppler-displacements are.

According to the Lorentz transformation the effects are zero in transverse directions.

(3) The radiation theory predicts that relativity effects will diminish from a maximum in directions coinciding with or opposite to the direction of motion of bodies to zero in directions transverse thereto in accordance with the cosine law, because Doppler-displacements do.

According to the Lorentz transformation, the effects thus diminish in accordance with the cosine law.

(4) The radiation theory predicts that relativity effects will approach zero as the velocity of bodies approaches zero, because Doppler-displacements do.

According to the Lorentz transformation, relativity effects approach zero as the velocity of bodies approaches zero.

(5) The radiation theory predicts that relativity effects will approach infinity as the velocity of bodies approaches that of radiation, because Doppler-displacements do.

According to the Lorentz transformation, relativity effects approach infinity as the velocity of bodies approaches that of radiation (light).

(6) The radiation theory predicts that relativity effects will be functions of c/n instead of c alone, when the index of refraction of the medium through which the body is moving is n, because Doppler-displacements are.

According to the fully expressed Lorentz transformation, relativity effects are functions of c/n instead of c alone, when the index of refraction of the medium through which the body is moving is n.

(7) The radiation theory predicts that the relativity theory will be divided into two parts, according as the motion of the bodies subject to relativity effects is uniform or accelerated, because the Doppler-displacements in the two cases follow different laws.

According to the relativity equations, the relativity theory divides into two parts, the first, or special theory applying exclusively to uniform motion, and the second, or general theory applying exclusively to accelerated motion, this division being required because it is found that, to conform to the facts, the equations in the two cases must follow different laws.

(8) The radiation theory predicts that of the two parts into which the relativity theory will be divided, the one applying to uniform motion will be a limiting case of the one applying to accelerated motion, because the Doppler-displacements due to uniform motion are limiting cases of those due to accelerated motion.

In accordance with this prediction, the equations of the special theory of relativity are limiting cases of those of the general theory.

(9) The radiation theory predicts a variation of gravitation with distance conforming to the inverse square law, because the unbalanced radiation pressure, which it assigns as the cause of gravitation, follows that law.

According to Newton, and all physicists following him, the variation of gravitation with distance conforms to the inverse square law.

(10) The radiation theory predicts a propagation of gravitation with the velocity of light, because the radiation whose pressure it assigns as the cause of gravitation is propagated with that velocity.

According to many eminent modern physicists, including Einstein and Eddington, gravitation is propagated with the velocity of light.

(11) The radiation theory predicts dependence of potential energy upon motion, because of its dependence upon the transmutation of kinetic energy in bodies into energy of ethereal radiation.

According to Tait (other physicists agreeing), "We are . . . forced to the conclusion that potential energy . . . depends (in some as yet unexplained, or rather unimagined way) upon motion."[4]

(12) The radiation theory predicts proportionality between the inertia and gravitation of bodies, irrespective of their size, because the energy exchange to which that theory attributes inertia, and the exchange to which it attributes gravitation, are exchanges with the same material units which constitute bodies.

According to the facts, as first demonstrated by Galileo at Pisa, such proportionality between the inertia and gravitation of bodies, irrespective of size, is observable.

(13) The radiation theory predicts deviations from the inverse square law of gravitation when the gravitating bodies are in relative motion, because of the Doppler-displacements accompanying such motion.

According to the general theory of relativity, and generally accepted inferences from the observed rate of rotation of the perihelion of the planet Mercury, deviations of the order of magnitude predicted, occur.

(14) The radiation theory predicts an increase of mass with motion, according to the well-known equation

$$M_v = M_o \frac{1}{\sqrt{1 - \frac{V^2}{C^2}}}$$

because, as shown by Larmor,[5] this equation is of the form which expresses the increase of radiation with velocity (V) of its source.

According to the theories, both of Lorentz and of Einstein, and the facts of the Kaufmann-Bucherer experiment, an increase of mass with motion according to the equation

$$M_v = M_o \frac{1}{\sqrt{1 - \frac{V^2}{C^2}}}$$

occurs.

(15) The radiation theory predicts that the variation of the

[4] *Encyclopedia Brittannica*, 9th edition, Vol. XV, p. 748.

[5] *Collected Scientific Papers of J. H. Poynting*, p. 755.

mass and diameter of bodies with motion, if any variation of diameter occurs, shall be concomitant, because due to a common cause, namely, motion relative to a radiant ether.

According to the theories both of Lorentz and of Einstein, based on the Michelson-Morley and Kaufmann-Bucherer experiments, the variations of mass and diameter of bodies with motion are reciprocals of each other, and hence quantitatively concomitant.

(16) The radiation theory predicts that the Doppler-effect in light (but not in sound) will be interpreted by the relativists as an effect depending upon the relativity of time and length, because this effect is a Doppler-displacement.

According to the relativist interpretation, the Doppler-effect in light (but not in sound) is an effect depending upon the relativity of time and length.

(17) The radiation theory predicts that the effects on light by moving matter discovered by Fizeau and Airy, respectively, will be interpreted by the relativists as effects depending upon the relativity of time and length, because, at the velocities involved in the Fizeau and Airy experiments, neither are distinguishable from Doppler-displacements.

According to the relativist interpretation, the Fizeau and Airy effects are effects depending upon the relativity of time and length.

Here are seventeen verifications of the radiation theory, and if time permitted, I could add others to them. If that theory is untrue, they must be regarded as a mere combination of coincidences. Perhaps they are, but what are the chances that seventeen, or even seven, casual coincidences would thus conspire to simulate causal ones? Among these verifications, indeed, are three, any one of which appears to be an *experimentum crucis* in favor of the hypothesis that the relativity definitions disguise a radiation displacement. I refer to the three effects last mentioned. For in these particular cases, the radiation displaced is neither more nor less than that familiar to us as light, and hence no theorizing is required in order to discover what the relativity definitions are disguising. Moreover, to complete the evidence, Einstein himself not only admits, but insists, that there is no opposition between the relativity and non-relativity explanations of these effects. In short, both are true; and how can both be true unless one is a disguise for the other? In the Doppler, Fizeau, and Airy effects, then, we have veritable Rosetta Stones of Relativity, on which are inscribed the dimensional and non-dimensional explanations side by side, the first in the mysterious language of relativity, the second in the familiar language of radiation displacement—and the translation reveals what the radiation theory predicts.

This statement of the evidence for the radiation theory must suffice for the present paper. It is a very incomplete statement, but represents fairly the evidence as a whole. If the radiation theory is sound, however, it is plain that Einstein has discovered nothing about time, space, motion, or acceleration unknown to the Newtonians, or shown that what they have hitherto assumed about those magnitudes is contrary to any fact in nature. What, then, has he done that is important to physics and to science in general? I submit that the evidence herein presented appears to indicate that what he has done is simply this: He has, by means of very great mathematical genius, succeeded in hitting upon the dimensional disguise for the Doppler-displacements of a radiant ether, which are inevitable if human beings, contrary to what has been hitherto assumed, inhabit a dynamic, instead of a static, universe.

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BOOK REVIEWS

Coleridge on Logic and Learning; with selections from the unpublished manuscripts. ALICE D. SNYDER.

Professor Snyder's study of Coleridge's system of thought and theories of education is based almost entirely on unpublished manuscripts. It illustrates most forcibly the large amount of work Coleridge actually did accomplish in his later life, which is quite contrary to the popular belief that he planned and dreamed only. Students of his manuscripts in the past few years have just begun to investigate them and to realize the possibilities and importance they hold in creating a change of view regarding his industry or of his genuine efforts to carry out what he often discusses in his letters and conversations, though so little of it was ever given to the world during his lifetime; and that which was edited after his death suffered considerably by the scruples of his editors. With the exception of Henry Nelson Coleridge's editions of the marginalia and notes, dating from 1836 to 1839, and Ernest Hartley Coleridge's edition of the *Anima Poeta* and *Letters* in 1895, there has been not a single significant volume of prose issued which contains wholly new material, until the appearance of this book by Professor Snyder. Even the numerous studies of Coleridge's *sources* only too frequently fail to include fresh matter, with, of course, the outstanding exception of Professor Lowe's *The Road to Xanadu.* As a matter of fact, serious research in Coleridgeiana is only of recent date.

The Coleridge student has had to content himself with meagre