Einstein and Marx

What the Theory of Relativity Is All About

by Will Herberg

This is the second of a series of three articles "Einstein and Marx." The first article, which appeared last week, dealt with "How Einstein 'Made' the First Page." The third article, which will appear next week, will be entitled: "Relativity, Modern Science and Dialectic Materialism."

No connected *explanation* however brief, of the outstanding Einsteinian conceptions of space, time, mass, energy, gravitation, field and the structure of the universe, can be expected in this article. Merely to *formulate* these conceptions in an intelligible manner would require many times the space of these paragraphs, and would demand technical and mathematical treatment altogether out of question in an article of this character. All that will be attempted here is to give a general survey of the leading ideas of the theory of relativity with the double purpose of indicating the profound significance of Einstein's contributions to physical science and of making possible some sort of independent examination of the relations between relativity, modern science and dialectic materialism.

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The Foundations of the Theory

Contrary to the general impression the theory of relativity does not emerge from any sort of mystical contemplation of general abstractions. It arises as a chain of logical deductions from two very concrete and empirically verified physical facts.

The first of these principles can be explained in very simple terms. Let us assume a railroad train moving smoothly at a constant rate along straight rails. Then the "principle of relativity" declares that: no physical experiment or observation made on the train alone can tell you if the train is standing still or is moving. Of course, you can settle this question by looking out of the window and seeing the station flash by.

But then you will be going *outside* the train itself in your observations. And even if you do look out you have no way of telling definitely whether it is the train that is moving and the station that is standing still or vice versa. Indeed, as far as all natural laws are concerned, it makes no difference whatever which you consider to be so: all that is important is that there is a *relative* motion between the train and the station. Now the train and the station are each what is called a "system of reference." This means that each may be used to fix the position of a certain object and the time of a certain event. For instance, we may say that a certain object is 2 feet from the floor of the train, 10 feet from its front end and 5 feet from its left wall. Also we may say that a certain event happens so many seconds after midnight on Monday. Of course the same object may be fixed with reference to the station: so many feet from the floor, so many from the north wall, so many from the east wall. And likewise for fixing the time of an event. Expressing these ideas in condensed form we may formulate the "principle of relativity" as follows: that from measurement on a system of reference itself it cannot be determined whether the system is at rest or whether it is moving in a straight line at uniform speed. This is equivalent to saying that as far as physical phenomena are concerned it makes no difference in fact, whether the system of reference is at rest or is in uniform straight-line motion.

The second of the two principles is the "principle of the constancy of the velocity of light": that the velocity of light (in a vacuum) is constant (equal to about 186,000 miles a second) no matter what is the state of motion of its source or of the observers. Neither of these two principles is particularly new or at all paradoxical; each is a well-known empirical fact. What Einstein did was to draw (by means of mathematics) the direct logical consequences of these two principles taken together. And these logical consequences have been so far-reaching that they have profoundly affected the theoretical and philosophical foundations of science.

The methodological approach of Einstein is very important. With the greatest thoroness Einstein insists on the idea as fundamental that "what cannot *essentially* be observed cannot be said to exist." To Einstein, "space", "time", "motion", etc. have significance only in so far as they can be *measured* (i. e. as they appear in human practice). The definition of any of these entities is essentially equivalent to an explanation of how it is measured. This is a fundamental feature of Einstein's method.

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"Absolute" Time and Space

The rejection of the conceptions of "absolute space" and "absolute time" are quite basic in Einstein's system. These conceptions seem quite "natural" to us; they are "common sense". We all believe that time just "flows along" and that events are "in time" just as water is in a vessel. In the same way we all believe that space just "extends" quite independently of whether there are objects "in it" or not. Isaac Newton, who laid the foundation of classical mechanics and of modern science in general, formulated these ideas in precise form:

> "Absolute . . . time, of itself, and from its own nature, flows equably without regard to anything external . . ."
>
> "Absolute space, in its own nature, without regard to any thing external remains similar and immovable."

Now Einstein positively rejects the very idea of these "absolutes". True to his fundamental belief that "what cannot essentially be observed cannot be said to exist", he insists that space is "relative"—a *relation* between objects; that time is relative—a *relation* between events. *Without objects and without events there would be neither time nor space.*

Exactly the same applies to "absolute motion". In human practise and therefore in human conception, motion is always motion in relation to something we arbitrarily consider at rest. But as far as all physical facts are concerned, that "something" may be considered in motion and the first object at rest. What is given in experience is therefore *relative* motion between objects—"absolute motion" is a fiction entirely outside of human experience.

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Some Conclusions

These general considerations lead to the heart of the paradoxical conclusions of the theory of relativity. It is easily demonstrable that if two systems of reference (A and B) are in relative straight-line motion (e.g., a train moving along straight tracks at constant speed and the station platform) then the following strange things occur:

(1) Objects on System B appear to A to be shorter in the direction of motion than they appear to B.

(2) This fact is reciprocal. Ob-



Albert Einstein

jects in System A appear to B to be shorter than they appear to A.

(3) Events on System B appear faster to A than do to B. This also is reciprocal.

(4) Events which are simultaneous on one system are not so on the other.

Since neither system can be considered "absolutely" at rest and the other in motion, *the observations of both A and B are equally valid.* Therefore space-intervals and time-intervals are not something absolute and independent of everything else; they are dependent upon and relative to the relative motion between the space-interval (or time-interval) and the observer. This may seem to be very strange at first sight but there are many ordinary things which are relative to the condition of the observer. For example, whether a certain city is East or West depends upon where the observer is; or again, the angle at which we see an object (perspective) depends upon the position of the observer. Einstein proves that the space and time-interval between two events depends upon relative union.

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A Space-Time World

The conclusions reached by Einstein for uniform relative motion (the "Special Theory of Relativity") he later generalizes for all sorts of motion (the "General Theory of Relativity"). It is quite out of the question to give here all of the conclusions Einstein reaches in this direction but certain of the most important features may be mentioned.

According to the old (Newtonian) physics, space and time are absolutely distinct. The distance between two points (space-interval), in Newtonian mechanics, remains the same no matter what system of reference is used; it is *invariant*. The same is held to be true of the time between two events (time-interval). But Einstein shows that actually this is not so. Both space-intervals and time-intervals change according to the relative motions of the systems of reference: what remains invariant is a certain relation between space and time. Einstein has confirmed the brilliant vision of the German mathematician, Minkowski, who declared in 1908:

> "From this day forth, space taken by itself and time by itself are to become mere shadows and only a kind of union of both is to retain independence."

Instead of a space-world existing side by side with but utterly independent of a time-world, we have a *unified space-time world.*

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Matter, Energy and Space

Still doggedly pursuing the logical consequences of empirically ascertained principles, Einstein proceeds to examine the relations between mass (matter) and energy. Like space and time, mass and energy have always been regarded in the old physics as utterly distinct. The law of the conservation of matter (a basic law of the old physics) declares that, in spite of all physical and chemical changes, the total mass in a closed system (the universe) remains constant. The law of the conservation of energy declares that the total energy of a closed system remains constant in spite of all changes of form. But no change of mass is supposed to produce any change upon energy nor energy upon mass. But Einstein destroys this Chinese wall of separation between mass and energy: Einstein was able to show that there is a fundamental relation between the two. An increase of energy he proves —is equivalent to an increase of mass, and it is very likely that the total mass of a body is a function of total energy and vice versa. What is invariant (constant) now is not the mass-total or the energy-total but a certain relation between these totals. Again a unity arises out of two disparate entities.

A direct conclusion from this conception of the equivalence of mass and energy is the fact that space can no longer be considered as "empty". Energy in some form or other pervades the universe and therefore so does mass. Matter and space between co-extensive. Material objects, like tables and chairs and men and trees, are certain forms of energy-content —"wrinkles" or "distortions" in space. It would be absolutely out of the question to attempt to describe here even in the most inadequately general terms, Einstein's investigations into the nature of gravitation and above all his strikingly brilliant conception of the universe. Ordinary language is inadequate to convey these ideas; the language of mathematics is quite essential.

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Relativity and Experience

The actually calculable differences in results between the formulas of Einsteinian physics and those of classical (Newtonian) physics are very, very small—absolutely beyond the limits of present-day technique of measurement. Yet empirical verification of Einstein's conclusions is not lacking. Since the famous solar eclipse in 1919, in which the "bending" of the rays of light as predicted by Einstein was observed, there have been all sorts of experiments and observations contrived to check the predicitions and conclusions of Einstein's theories. Most of these have turned out positively, i. e., confirmed the predicitions; some were ambiguous and indecisive; none have been negative, i. e., contrary to the predictions. From another direction, also, a number of phenomena, which have never found any explanation on the basis of Newtonian mechanics, have been fully explained on the basis of relativity physics (e. g., the peculiar behavior of the orbit of the planet Mercury). It can be very conservatively said that, altho many of the features of the relativity theory (especially of the general theory) are still considerably hypothetical, its general outlines and fundamental ideas are not only strictly logical conclusions of well-established facts but have been largely confirmed by experiment and observation.

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Significance of the Theory

It will be obvious to any one even from the bare description given above that the significance of the theory of relativity extends not merely to the special problems of physics but that it has important consequences in the realm of philosophy. For reasons pointed out in the first article most contemporary scientists have consistently attempted to use the conceptions of relativity for the purpose of strengthening the case of philosophic idealism and of undermining the foundations of materialism.

Is there any validity in this attempt?

What are the philosophical implications of the theory of relativity?

These matters will be discussed in the final article of the series.

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(1) for a simple but valuable exposition of the theory of relativity the following two books are recommended: *Einstein's Theories of Relativity and Gravitation, A Selection of Material from the Essays Submitted in the Competition for the Eugene Higgins Prize of* $5,000. *New York, Scientific American Publishing Co.,* 1922 *and The Ideas of Einstein's Theory, by J. H. Thirring. New York, Robert M. McBride & Company,* 1922.