

Does Einstein's Theory Really Imply Time Travel?

Science versus Science Fiction*

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Over the past century and to the present time, science fiction writers have often used the theme of time travel in their stories – H. G. Wells' *The Time Machine*, the recent film, *Back to the Future*, the TV series, *Star Trek*, etc. – to name a few.

This is all right so long as it is emphasized that these stories are purely science fiction, written for the purpose of entertainment. They are not works that pursue scientific truth!

But in recent times, some bona fide scientists have joined the chorus in claiming that pure science does indeed imply the possibility of time travel - from the present to the past and into the future. Their argument is usually based on faulty interpretations of Einstein's theory of relativity.

I would like to discuss with you today exactly what it is that Einstein's theory is all about, how the time measure comes into it and then how this does not at all relate to the phenomenon of 'time travel'. First, what does 'time travel' refer to? It refers to a sequence of physical experiences that a human being (or any other living creature) may have, in moving into the past or into the future. That is, this is not just viewing the past or the future, as on a TV screen, but interacting with it! This possibility leads to some unacceptable logical paradoxes – conclusions that could not possibly be scientifically true!

Consider a doctor of medicine in 1997, who travels to a previous time, 70 years earlier in 1927, when he meets his own father, before his father has met his mother. Suppose that this doctor should force his father onto a surgery table and then operate to make him sterile. That is, the doctor causes his father to be unable to reproduce children, before he met his mother. Thus, the doctor could never have been conceived in the first place – he does not exist! But he does exist in taking this trip into the past to have this experience!

This is a logical, paradox: That the doctor exists and he does not exist. This is clearly unacceptable as a scientific conclusion!

Some who believe in the generalizations of the spatial geometry in general relativity, leading to 'wormholes' in the space that connect different universes, claim that they have a way out of the paradox. What they say is that when the doctor operates on his father to make him sterile, before the doctor was conceived, this occurs in one universe. But in a different universe that is connected to this one by means of a 'wormhole', this set of events does not happen. In my view, this is a purely nonsensical and unscientific answer to the problem. It insults the scientists', as well as the interested lay public's intelligence! It would be like saying that my plane that flew from New York to Japan encountered a giant wind that threw it off course, so that it landed instead in Australia. But I am here in Japan because in a different, parallel universe the giant wind did not happen, so that the plane did land here.

The parallel universe idea comes from a misinterpretation of the generalization of the geometry of spacetime in general relativity theory, as it was analyzed by Einstein and Rosen. Theirs is a more general way of expressing the *language* of the laws of nature, wherein the spacetime is multiply connected, with 'wormholes' connecting the different geometrical domains. It is not supposed to be a change of the matter of the universe with physical tunnels connecting different physical universes!

Another well known example that yields a paradox because of a faulty interpretation of relativity theory has to do with travel to a distant star. Suppose that the space traveler wishes to go to a distant star system that is 50 light-years away from Earth. This would mean that if the traveler should move at the speed of light, he or she would arrive at the star in 50 years. But the formulas from special relativity theory imply that there must be a contraction of the time measure for an object that moves relative to an observer. Thus, from the reference frame of the star, the pilot flies close to the speed of light toward the star, and the contraction formula implies that, from the star's perspective, he or she may reach the star in only one minute of the pilot's lifetime, rather than 50 years. In the meanwhile the star will have used up 50 years worth of its nuclear fuel in this time of the

pilot's travel. However, from the reference frame of the pilot, who would see the star moving toward his ship and the earth receding, the star of his destination would be coming toward him at close to the speed of light. Thus while it would take the pilot 50 years to reach the star, the star would have only used up one minute's worth of its nuclear fuel in the same travel time! The conclusion must then be reached that during the travel time of the pilot, the star used up 50 years worth of its fuel and it used up one minute's worth of its fuel. Of course, both statements cannot be simultaneously true! This is a paradox. It is unacceptable as a scientific explanation of a phenomenon!

Why is this claim of the peculiar, paradoxical time travel made? It is because of the faulty interpretation of the motion-dependent variability of the time measure (the Lorentz transformation) in relativity theory. Let us start, then, with the basic premise of the theory of relativity – *the principle of relativity*. This is the assertion that the laws of nature have expressions in all possible frames of reference, from the view of any one particular one of them, that are in *one-to-one correspondence*. That is to say, the claim is made that the laws of nature are fully objective – that their form for any phenomenon in nature, is independent of any particular reference frame in which they may be represented, from any other, say that of an observer.

This does not mean that the languages that are used to express the law of nature, in terms of space and time measures, or other sets of parameters, are the same – they are not! It only means that the laws, expressed in the different reference frames, are in exact correspondence, if they are indeed true laws of nature. For example, in Japanese, *aijo* means *to love*. But the essence of 'love' is the same in the Japanese reference frame as it is in the English frame of reference. That is to say, the essence of the law of nature is the same, whether expressed in the spacetime language of one reference frame or another that is in motion relative to the first. This is the meaning of *the principle of relativity* – the assertion that underlies Einstein's theory of relativity.

The principle of relativity implies that there must be two underlying assumptions: 1) there are laws of nature to underlie all cause-effect relations, and 2) these laws can be comprehended by us and expressed. The latter assumption is where the space and time

parameters come into the theory of relativity. We have found that the most efficient language to express the laws of nature is in terms of ‘words’ that are four continuously varying parameters. We identify three of them with a three dimensional measure of spatial extension and the fourth with a measure of time. These are the words that are used to facilitate an expression of the laws of nature in terms of particular relationships that predict physical phenomena, such as the predictions of all of the physical features of a burning candle. Then, the transformations of these ‘spacetime words’ to a different reference frame, analogous to the translations between Japanese and English, must be such that the laws of the burning candle is preserved in both languages. If an English speaking person knows Japanese, and knows that it exactly corresponds with his expression of the law in English, then he knows that this is a scientifically true expression to explain the phenomenon of the burning candle.

This is the meaning of Einstein’s *principle of relativity* – that whenever transforming a law (changing languages) from one reference frame to another, the form of the law is preserved. What Einstein discovered was that if the different reference frames are distinguished in terms of constant relative motion in a straight line between them, (these are called ‘inertial frames of reference’ – this symmetry is called ‘special relativity’) it is necessary to contract the *scales* of time measure and space measure, in a particular way, in order to preserve the form of the law of nature in both frames.

The contraction of the space and time scales and their measures does not mean that anything physical has happened to the object that is moving relative to an observer of this moving object. It might correspond, instead, to the need to use eight numbers on the face of the moving clock, rather than twelve, from the view of the observer, in order to preserve the form of the law in the moving frame, from the view of the observer. It does not mean that anything physical is happening to the works of the clock behind its face, by virtue of its motion, that is different from the fixed clock in the observer’s frame of reference.

If one should (falsely) assume that the scale contraction does imply that physical entities, such as the physical length of a material stick, or the location of the hands of a clock, are

altered by virtue of the motion of the material body, it would lead to a paradox – that the stick would be short and its would be long compared with the measures of the stick in the observer’s frame of reference, or that the hands of the clock would be both slow and fast compared with the observer’s clock – because of the *relativity of the motion* in regard to the laws of nature (as Galileo discovered 400 years ago!) Such a paradoxical conclusion is, of course, unacceptable as a scientific statement!

Finally, there is the question of time travel in the context of relativity theory. This is sometimes claimed because of the unification of space and time measures in the theory’s requirement to satisfy the *principle of relativity*. What Einstein actually discovered was that to translate the space and time measures in a way that would keep the laws of nature fully objective in their comparison in the different frames of reference, it is necessary to fuse the space and time measures in such a way that a purely spatial measure in one reference frame must be expressed as a particular mixture of spatial and temporal measures in different, relatively moving reference frames. Thus, space and time become spacetime. There is no longer any objective meaning for a purely spatial or a purely temporal measure. Objectively, there is only one spacetime measure, though under special, *subjective* physical conditions, it may be viewed as purely spatial or purely temporal.

Some physicists and fiction writers have used the argument that if time is on the same conceptual footing as space, then if one can move in space, from east to west or from up to down, one should be able to move in time, from the present to the past or the future. This is certainly a false conclusion. Travel in time for a human being, from the present to the past or the future would be a sequence of physical experiences. The time and space measures, on the other hand, are not more than the ‘words’ that we use to facilitate an expression of the laws of nature! The contraction of the scales of space and time measures, or time travel, are then not in themselves physical phenomena.

Thus, in science, as distinct from science fiction, there is no prediction of ‘time travel’ as a physical possibility!

