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A REMARK ABOUT THE RELATIONSHIP BETWEEN RELATIVITY THEORY AND IDEALISTIC PHILOSOPHY

ONE of the most interesting aspects of relativity theory for the philosophical-minded consists in the fact that it gave new and surprising insights into the nature of time, of that mysterious and seemingly self-contradictory[1] being which, on the other hand, seems to form the basis of the world's and our own existence. The very starting point of special relativity theory consists in the discovery of a new and very astonishing property of time, namely the relativity of simultaneity, which to a large extent implies[2] that of succession. The assertion that the events A and B are simultaneous (and, for a large class of pairs of events, also the assertion that A happened before B) loses its objective meaning, in so far as another observer, with the same claim to correctness, can assert that A and B are not simultaneous (or that B happened before A).

Following up the consequences of this strange state of affairs one is led to conclusions about the nature of time which are very far reaching indeed. In short, it seems that one obtains an unequivocal proof for the view of those philosophers who, like Parmenides, Kant, and the modern idealists, deny the objectivity of change and consider change as an illusion or an appearance due to our special mode of perception.[3] The argu-

[1] Cf., e.g., J.M.E. McTaggart, "The Unreality of Time." *Mind*, 17, 1908.

[2] At least if it is required that any two point events are either simultaneous or one succeeds the other, i.e., that temporal succession defines a complete linear ordering of all point events. There exists an absolute partial ordering.

[3] Kant (in the *Critique of Pure Reason*, 2. ed., 1787, p. 54) expresses this view in the following words: "those affections which we represent to ourselves as changes, in beings with other forms of cognition, would give rise to a perception in which the idea of time, and therefore also of change, would not occur

ment runs as follows: Change becomes possible only through the lapse of time. The existence of an objective lapse of time,[4] however, means (or, at least, is equivalent to the fact) that reality consists of an infinity of layers of "now" which come into existence successively. But, if simultaneity is something relative in the sense just explained, reality cannot be split up into such layers in an objectively determined way. Each observer has his own set of "nows," and none of these various systems of layers can claim the prerogative of representing the objective lapse of time.[5]

This inference has been pointed out by some, although by surprisingly few, philosophical writers, but it has not remained

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at all." This formulation agrees so well with the situation subsisting in relativity theory, that one is almost tempted to add: such as, e.g., a perception of the inclination relative to each other of the world lines of matter in Minkowski space.

[4] One may take the standpoint that the idea of an objective lapse of time (whose essence is that only the present really exists) is meaningless. But this is no way out of the dilemma; for by this very opinion one would take the idealistic viewpoint as to the idea of change, exactly as those philosophers who consider it as self-contradictory. For in both views one denies that an objective lapse of time is a possible state of affairs, *a fortiori* that it exists in reality, and it makes very little difference in this context, whether our idea of it is regarded as meaningless or as self-contradictory. Of course for those who take either one of these two viewpoints the argument from relativity theory given below is unnecessary, but even for them it should be of interest that perhaps there exists a second proof for the unreality of change based on entirely different grounds, especially in view of the fact that the assertion to be proved runs so completely counter to common sense. A particularly clear discussion of the subject independent of relativity theory is to be found in: Paul Mongré, *Das Chaos in kosmischer Auslese*, 1898.

[5] It may be objected that this argument only shows that the lapse of time is something relative, which does not exclude that it is something objective; whereas idealists maintain that it is something merely imagined. A relative lapse of time, however, if any meaning at all can be given to this phrase, would certainly be something entirely different from the lapse of time in the ordinary sense, which means a change in the existing. The concept of existence, however, cannot be relativized without destroying its meaning completely. It may furthermore be objected that the argument under consideration only shows that time lapses in different ways for different observers, whereas the lapse of time itself may nevertheless be an intrinsic (absolute) property of time or of reality. A lapse of time, however, which is not a lapse in some definite way seems to me as absurd as a coloured object which has no definite colours. But even if such a thing were conceivable, it would again be something totally different from the intuitive idea of the lapse of time, to which the idealistic assertion refers.

unchallenged. And actually to the argument in the form just presented it can be objected that the complete equivalence of all observers moving with different (but uniform) velocities, which is the essential point in it, subsists only in the abstract space-time scheme of special relativity theory and in certain empty worlds of general relativity theory. The existence of matter, however, as well as the particular kind of curvature of space-time produced by it, largely destroy the equivalence of different observers[6] and distinguish some of them conspicuously from the rest, namely those which follow in their notion the mean motion of matter.[7] Now in all cosmological solutions of the gravitational equations (i.e., in all possible universes) known at present the local times of all *these* observers fit together into one world time, so that apparently it becomes possible to consider this time as the "true" one, which lapses objectively, whereas the discrepancies of the measuring results of other observers from this time may be conceived as due to the influence which a motion relative to the mean state of motion of matter has on the measuring processes and physical processes in general.

From this state of affairs, in view of the fact that some of the known cosmological solutions seem to represent our world correctly, James Jeans has concluded[8] that there is no reason to abandon the intuitive idea of an absolute time lapsing objectively. I do not think that the situation justifies this conclu-

[6] Of course, according to relativity theory all observers are equivalent in so far as the laws of motion and interaction for matter and field are the same for all of them. But this does not exclude that the structure of the world (i.e., the actual arrangement of matter, motion, and field) may offer quite different aspects to different observers, and that it may offer a more "natural" aspect to some of them and a distorted one to others. The observer, incidentally, plays no essential rôle in these considerations. The main point, of course, is that the world itself has certain distinguished directions, which directly define certain distinguished local times.

[7] The value of the mean motion of matter may depend essentially on the size of the regions over which the mean is taken. What may be called the "true mean motion" is obtained by taking regions so large, that a further increase in their size does not any longer change essentially the value obtained. In our world this is the case for regions including many galactic systems. Of course a true mean motion in this sense need not necessarily exist.

[8] Cf. *Man and the Universe*, Sir Halley Stewart Lecture (1935), 22-23.

sion and am basing my opinion chiefly[9] on the following facts and considerations:

There exist cosmological solutions of another kind[10] than those known at present, to which the aforementioned procedure of defining an absolute time is not applicable, because the local times of the special observers used above cannot be fitted together into one world time. Nor can any other procedure which would accomplish this purpose exist for them; i.e., these worlds possess such properties of symmetry, that for each possible concept of simultaneity and succession there exist others which cannot be distinguished from it by any intrinsic properties, but only by reference to individual objects, such as, e.g., a particular galactic system.

Consequently, the inference drawn above as to the non-objectivity of change doubtless applies at least in these worlds. Moreover it turns out that temporal conditions in these universes (at least in those referred to in the end of footnote 10) show other surprising features, strengthening further the idealistic viewpoint. Namely, by making a round trip on a rocket ship in a sufficiently wide curve, it is possible in these worlds to travel into any region of the past, present, and future, and back again, exactly as it is possible in other worlds to travel to distant parts of space.

This state of affairs seems to imply an absurdity. For it enables one e.g., to travel into the near past of those places where

[9] Another circumstance invalidating Jeans' argument is that the procedure described above gives only an approximate definition of an absolute time. No doubt it is possible to refine the procedure so as to obtain a precise definition, but perhaps only by introducing more or less arbitrary elements (such as, e.g., the size of the regions or the weight function to be used in the computation of the mean motion of matter). It is doubtful whether there exists a precise definition which has so great merits, that there would be sufficient reason to consider exactly the time thus obtained as the true one.

[10] The most conspicuous physical property distinguishing these solutions from those known at present is that the compass of inertia in them everywhere rotates relative to matter, which in our world would mean that it rotates relative to the totality of galactic systems. These worlds, therefore, can fittingly be called "rotating universes." In the subsequent considerations I have in mind a particular kind of rotating universes which have the additional properties of being static and spatially homogeneous, and a cosmological constant < 0. For the mathematical representation of these solutions, cf. my paper forthcoming in *Rev. Mod. Phys.*

he has himself lived. There he would find a person who would be himself at some earlier period of his life. Now he could do something to this person which, by his memory, he knows has not happened to him. This and similar contradictions, however, in order to prove the impossibility of the worlds under consideration, presuppose the actual feasibility of the journey into one's own past. But the velocities which would be necessary in order to complete the voyage in a reasonable length of time[11] are far beyond everything that can be expected ever to become a practical possibility. Therefore it cannot be excluded *a priori*, on the ground of the argument given, that the space-time structure of the real world is of the type described.

As to the conclusions which could be drawn from the state of affairs explained for the question being considered in this paper, the decisive point is this: that for *every* possible definition of a world time one could travel into regions of the universe which are passed according to that definition.[12] This again shows that to assume an objective lapse of time would lose every justification in these worlds. For, in whatever way one may assume time to be lapsing, there will always exist possible observers to whose experienced lapse of time no objective lapse corresponds (in particular also possible observers whose whole existence objectively would be simultaneous). But, if the experience of the lapse of time can exist without an objective lapse of time, no reason can be given why an objective lapse of time should be assumed at all.

It might, however, be asked: Of what use is it if such conditions prevail in certain *possible* worlds? Does that mean anything for the question interesting us whether in *our* world there

[11] Basing the calculation on a mean density of matter equal to that observed in our world, and assuming one were able to transform matter completely into energy the weight of the "fuel" of the rocket ship, in order to complete the voyage in t years (as measured by the traveller), would have to be of the order of magnitude of $\frac{10^{22}}{t^2}$ times the weight of the ship (if stopping, too, is effected by recoil). This estimate applies to $t \ll 10''$. Irrespective of the value of t, the velocity of the ship must be at least $1/\sqrt{2}$ of the velocity of light.

[12] For this purpose incomparably smaller velocities would be sufficient. Under the assumptions made in footnote 11 the weight of the fuel would have to be at most of the same order of magnitude as the weight of the ship.

exists an objective lapse of time? I think it does. For, (1) Our world, it is true, can hardly be represented by the particular kind of rotating solutions referred to above (because these solutions are static and, therefore, yield no red-shift for distant objects); there exist however also *expanding* rotating solutions. In such universes an absolute time also might fail to exist,[13] and it is not impossible that our world is a universe of this kind. (2) The mere compatibility with the laws of nature[14] of worlds in which there is no distinguished absolute time, and, therefore, no objective lapse of time can exist, throws some light on the meaning of time also in those worlds in which an absolute time *can* be defined. For, if someone asserts that this absolute time is lapsing, he accepts as a consequence that, whether or not an objective lapse of time exists (i.e., whether or not a time in the ordinary sense of the word exists), depends on the particular way in which matter and its motion are arranged in the world. This is not a straightforward contradiction; nevertheless, a philosophical view leading to such consequences can hardly be considered as satisfactory.

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[13] At least if it required that successive experiences of one observer should never be simultaneous in the absolute time, or (which is equivalent) that the absolute time should agree in direction with the times of all possible observers. Without this requirement an absolute time always exists in an expanding (and homogeneous) world. Whenever I speak of an "absolute" time, this of course is to be understood with the restriction explained in footnote 9, which also applies to other possible definitions of an absolute time.

[14] The solution considered above only proves the compatibility with the general form of the field equations in which the value of the cosmological constant is left open; this value, however, which at present is not known with certainty, evidently forms part of the laws of nature. But other rotating solutions might make the result independent of the value of the cosmological constant (or rather of its vanishing or non-vanishing and of its sign, since its numerical value is of no consequence for this problem). At any rate these questions would first have to be answered in an unfavourable sense, before one could think of drawing a conclusion like that of Jeans mentioned above. *Note added Sept. 2, 1949:* I have found in the meantime that for *every* value of the cosmological constant there do exist solutions, in which there is no world-time satisfying the requirement of footnote 13. *K.G.*