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**A CRITIQUE OF SPACETIME
THE BERGSON-EINSTEIN CONTROVERSY**

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'It is characteristic of thought in physics .. that it endeavours in principle to make do with "space-like" concepts alone .. (thus) the "now" loses for the spatially extended world its objective meaning.' A. Einstein: 'Relativity', app. 5 (Methuen).

INTRODUCTION

In what follows I will discuss the spatialization of time which occurred with the scientific revolution in the beginning of the 20th century. A reduction of time to space, chronology to geometry, was the core of Einstein's program for the development of physics, his scientific paradigm.

The thinker most strongly critical of the Einsteinian program was the philosopher Henri Bergson (1859-1941). Today it may be of interest to focus once more on what in its day was a famous and much-discussed controversy between two of the keenest intellectual powers of our century. How does their controversy appear in light of our own time's insight into the problems?

PHILOSOPHY IN THE DOGHOUSE

According to Bergson, the time characterized by physicists as the fourth dimension of space-time is not actually time, but on the contrary a spatialized form which by a process of abstraction has been teared out of the original unity of the human mind. Human consciousness is an incessant flux which was described by Bergson as continuous duration (fr. *durée*). Space-time's fourth dimension is unreal, since it reduces the dynamics of existence to something purely static.

Bergson fully acknowledged Einstein's great contributions to science. However, he audaciously expressed the opinion that he, Bergson, alone of all, had the correct interpretation of SR (Special Relativity). But physicists quickly taught him otherwise. For this reason not only Bergson, but also philosophy itself, whose most prominent spokesman he was, were set in the corner. The loss of prestige was tremendous and led to a drastic re-evaluation of the task of science. Philosophical thought was from that time on relegated to the humble rôle of serving the sciences.

THE EINSTEINIAN REVOLUTION

It is difficult to over-estimate the historic influence which proceeded from three small articles published by Einstein in *Annalen der Physik* in the year of 1905. One of these described the so-called Brownian motions; it later gained him the Nobel prize. The second examined the photo-electric effect on the basis of the quantum postulate; this led to a radical change in our view of the nature of light. The third paper developed SR, a theory which implied a radical suspension of the classical Newtonian concepts of time and space. Especially the dissolution of the notion of the absolute simultaneity of spatially separated events was the cause of a great stir in scientific circles.

SR did not meet with any immediate success. The first decisive break-through came with the observed bending of light-rays in the gravitational field of the sun during the solar eclipse of the year 1919. In accordance with the dominant positivistic climate at the time the result was generally interpreted as a clear victory for Einstein. The difference between successful verification and unsuccessful falsification was not appreciated by scientists, and Duhem's criticism of the idea of crucial experiments was conveniently ignored. SR is considered one of the best supported theories of physics, and the vast majority of scientists accept it today without hesitation. In spite of this, the evidence for the theory is ambiguous and indecisive.¹

A CLASH WITH SO-CALLED NAÏVE REALISM

Bergson set himself the task of mapping the philosophical premisses of SR. Quite naturally he utilized his own philosophy as his starting point. Along these lines, time is identical with the inner cohesion, the continuity, of our own consciousness. This inner, experienced time cannot be measured in an unqualified fashion; it can be measured only when we have equated it with movement, understood as the changing of relations between co-existing objects. However, to the same degree that temporality is abstracted from duration and spatialized, it is also bereft of its reality and reduced to an imaginary quantity. Recognition of the nature of time transcends the boundaries which science has laid down for itself. If physics wishes to concern itself with reality, it must plead for assistance from philosophy.

Of course this sounds very provocative. However, if Bergson had maintained nothing else his statements might properly have been ignored, in which case he would hardly have had the scientific establishment ranged against him. His theses might have been viewed as being purely metaphysical and open to criticism only by positivistic die-hardes who are eager to combat idealistic metaphysics. He went further, however, by

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unfolding a naïvely realistic view of the temporal structure of the external world based on sophisticated common-sense. Physicists who wished to legitimize the new world view with its lack of direct appeal to intuition sought for a convenient opportunity to make an example. Their confrontation with Bergson may be seen as a final renunciation of the ability to visualize science, hence also as a radical break with naïve realism.

BERGSON'S IDEAS OF TIME AND REALITY

The foundation of Bergsonianism is the understanding of time as being dynamic. In line with this view the temporal modalities - past, present, future - do not depend on the human mind alone, but are valid in nature, so their validity is not only subjective, but objective. For each mental activity a corresponding material condition is supposed. On the strength of this supposition, duration is combined with spatial extension in mutual agreement. Most physicists would be likely to agree with such a hypothesis. Time measurement in physics is based on clocks readings. A clock is a mechanism that enables us to express the duration of processes quantitatively by the counting of time. Analytical geometry then assimilates duration to distance - time is spatialized.

But the salient point is that Bergson generalized this concept of duration to encompass the entire universe. By this move he subscribes to a concept of simultaneity which from a relativistic point of view is just as illegitimate as the classical one is. According to Bergson the concepts of existence and duration are equally basic and in the end they are identical. Nature must be seen as a totality of simultaneous processes. Any comparison of distant clocks entails that there is a set of contemporaneous events distributed in space. This points to the existence of a basic simultaneity. It is impossible that this original simultaneity could permit of exception by rules later promulgated in order to coordinate the readings of distant clocks. SR, Bergson claimed, is precisely the theory suited above all others to provide the basis for an absolute universal time.

Now since SR, in contrast to CM (Classical Mechanics), operates with a wealth of different times, the problem is that of differentiating the real, privileged time from all others which are only imaginary. However, according to Bergson, this is not difficult. Since SR reckons all observers in inertial motion, together with their co-moving frames of reference, as being perfectly equivalent, each individual observer has the same right as has any other observer to consider his own frame of reference as being at rest and the others as being in motion. This means that the proper times of all the spatially distant clocks can only be compared on the supposition that each of the involved clocks is taken to be at rest. Hence any meaningful comparison of clocks presupposes all the clocks to be co-existing simultaneously, enduring the same basic natural rhythm.

As the basis for this unusual position Bergson differentiated between two types of relativity: unilateral and bilateral. *Unilateral relativity* refers to the point of view taken by the individual observer who considers his own frame of reference to be at rest and those of all the others to be in motion. *Bilateral relativity* on the contrary refers to the point of view taken by an observer who regards all inertial observers together with their various comoving frames as being equivalent. According to Bergson the first point of view is characteristic of the physicist, while the philosopher is characterized by the second and superior point of view. Due to his higher perspective the philosopher can arbitrate between the different observers and their clocks.

But here Bergson misses an important point. The confusing fact about SR is that clocks of identical construction are assumed to display different readings as a result of their relative motion, in spite of the fact that the clocks are supposed to be properly synchronized; this queer result is even claimed to be an inevitable consequence of their correct synchronization. In any case the movement is supposed to be relative, while the difference of the clock readings is claimed to be absolute. However, the problem is not, as Bergson thought, to make pairs of clocks in inertial collinear motion agree, but rather to make an entire set of moving clocks in inertial non-collinear motion agree.

According to SR, the concept of simultaneity is certainly reflexive and reciprocal, but not transitive; so one cannot speak of congruent clocks within SR unless the clocks belong to the same privileged equivalence class. Bergson misunderstood the problem by inferring transitivity of simultaneity-in-SR from reciprocity of simultaneity-in-SR. This conclusion is clearly based on an illegitimate short-cut.

SR INVOKES DEEP PHILOSOPHICAL PROBLEMS

But what is a frame of reference? Mathematically, the frame is an infinite set of points where each single point is determined by four coordinates; e.g. $P = (t, x, y, z)$. Physically, the frame can be visualized as a static lattice space of congruent cells having at least one clock and one mirror placed in each point of intersection. Assuming that light particles (photons) are transmitted with the same speed everywhere, that is, the speed of $c = \text{unity}$, such a frame can be constructed by sending out zig-zag light signals from the observer to the spatially distributed mirrors; cf. the radar principle.

Imagine an observer sending out a series of photons in all directions; the photons being reflected from the stationary mirrors, and the instants of emission and reception, resp. t_1 & t_3 , of each signal being noted. From this we can calculate the instant $t = t_2$ of the signal's reflection as well as the distance $r = r(t_2)$ of the reflecting mirror. According to the assumption $c = 1$ with validity in all directions we obtain the results: $t = (t_3 + t_1)/2$, $r = (t_3 - t_1)/2$. These are the SR standard coordinates of Einstein.

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Were we now to use the frame of reference thus constructed in order to measure the speed of light in a certain direction, we would be using the speed of light to measure the speed of light, thus reasoning in a vicious circle. According to the philosopher H. Reichenbach it is distinctive of *SR* in contrast to all other theories that the speed of light in one direction cannot be measured directly, but only fixed/determined by convention. Hence we are free to define the moment of reflection as: $t = t_1 + \epsilon(t_3 - t_1) = t_1 + 2\epsilon r$, where ϵ is an arbitrary number in the interval $[0,1]$, without changing the experimental consequences of *SR*. Analyses conducted by A. Grünbaum, J.A. Winnie og P. Øhrstrøm, have convincingly corroborated this point of view.⁴ So we shall consider it to be an established fact that the concept of simultaneity is based on convention within *SR*.

The philosophical consequences hereof are far-reaching. The point is that *SR*, by virtue of Reichenbach's thesis, poses a very serious problem for every form of realism (not alone the "naive" one). Astronomical distances are normally indicated as the speed of light multiplied by a certain measure of time. In this fashion the distance to the Moon is determined as ca. 1 light second, the distance to the Sun as ca. 8 light minutes and the distance to the star α -Centaurii as 4.7 light years. Hence we say that light has been resp. 1 second, 8 minutes, and 4.7 years underway from the light source in question.

But, as a consequence of Reichenbach's thesis these indications are reduced to so many illusive fictions. There is no definite measure of time which can be demonstrated to be the correct one. There is no possibility left for settling the issue by observation or experiment. Finally, it is of no avail to insist that standard coordinates are the simpler, for this may be challenged. In the cases just described, all numbers in a certain interval - for the Moon $[0,2]$ sec.s, for the Sun $[0,16]$ min.s, and for α Centaurii $[0,9.4]$ yrs. - can be termed equally correct, or equally incorrect.

As no instant in time can any longer be said to be uniquely given at any distance it at once becomes uncertain whether the universe at any given instant consists of these or some other objects or elements. The objective existence of the external world suddenly seems highly precarious. The problem which in the first place raised the question of which distant events we can consider as being simultaneous with ourselves just now, in the second round raises the question as to which distant objects we can legitimately ascribe reality, which amounts to the crucial question whether there is an external world

Are we forced, inspite of all, to accept the existence of a 4th-dimension space-time continuum? Must we after all accept a science which abandons the deepest human experience, viz. that of time's flow, and yet pretends to be a science built on experience? Bergson's reply is a candid and unambiguous: No!

REICHENBACH'S THESIS SUPPORTS BERGSON

In my opinion it is evident that only a very few physicists can have understood the thesis of the conventionality of simultaneity. By virtue of its consequences this thesis clearly demonstrates the invalidity of the orthodox interpretation of SR.

Let us suppose that two observers, P & Q , together with their frames of reference, find themselves in even mention on the same straight line. From the generalized version of LT (the Lorentz transformations) - I mean: both that of Winnie and that of Øhrstrøm - it now follows that it is possible to choose values of ϵ_P & ϵ_Q which eliminate both the retardation of clocks and the contraction of rods from the relationship between P & Q ! Two collinear frames, both provided with identical clocks placed equidistantly along the same straight line, pass in front of each other - and each time two clocks meet, one from each frame, they show exactly the same time! Will not most physicists feel surprised to learn that the situation just described is perfectly consistent and involves no conflict whatsoever with the established results of observation and experiment?!

This whole situation clearly demonstrates the possibility of giving an operational definition of the notion of identical construction as applied to clocks in uniform motion. This is very important since the concept alluded to has hitherto had a rather dubious status in the interpretation of SR. That atoms of the same type under the same external circumstances oscillate with the same natural frequencies is fundamental assumption which can now be shown to be in full accordance with SR. Clocks whose mechanisms are governed by such atoms are capable of being set to show the same time in spite of their motion if only they have been properly synchronized. The identical construction of the clocks concerned can likewise be tested by an external observer M permanently situated midway between P & Q , and relative to whom P & Q move with equal and opposite speeds, as the entire situation is then perfectly symmetrical relative to M .

For these reasons we conclude that SR is fully compatible with the crucial content of Bergson's assertion, viz., that clocks in uniform relative motion which are governed by identical atomic mechanisms are subject to the same cosmic rhythm. On account of this conclusion it seems justified to speak of a belated rehabilitation for Bergson in his controversy with Einstein. However, it is also mandatory to accept the fact that Bergson was mistaken in important respects, and that he often expressed himself in vague terms. His strength was visionary intuition, not trenchant reasoning.

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A VERITABLE "AARHUS STORY"

In spite of the fact that the stuff just mentioned should be well-known to scientists it is still announced at regular intervals that now - for God knows what number time - SR has been finally verified. Those journalists who with indefatigable enthusiasm bring such tidings to the fore have hardly understood very much. The latest example is still fresh in memory. I am referring to the much-discussed experiments carried out last year [1985] by a team of physicists from Aarhus who are said to have verified the relativistic time delay with unprecedented precision. This kind of claim always appears impressive to laymen who gladly accept such news as just another *cadeau* to Einstein.

Once in a while it can be amusing to stir up the ducks pond with a mighty splash. In my view, time is overdue for humanists to forsake the traditional humility towards natural science in order to set on a sudden attack. Since apparently no other humanists are possessed of the courage needed, I will risk my own neck by making a confession: in my view, all this talk of "final verification" is nothing but yet another "Aarhus story". But my purpose by forwarding this provocative remark should be properly understood: what I contest is not the experimental result, since I have no means of controlling that. What I am aiming at is solely its interpretation which I find outrageous.

Now, upon a closer reading of the paper in which the newly appointed "super-professor" Poulsen and his allies have announced their remarkable "conquest of land", it becomes apparent that it is almost emptied of considerations of a theoretical nature. The theory only takes effect by virtue of the authors' reference to three small papers written by Mausoursi & Sexl. In their papers these authors call attention to the fact that their arguments do not solely take aim at SR but instead concern a whole category of related theories of which not all can probably be differentiated experimentally from SR. Their most conspicuous result is a proof that the radar method and the method of slow clock transport yield identical synchronization of clocks if, and only if, their retardation due to inertial motion is expressible by the γ -factor characterizing SR.

Since the standard version of SR is distinguished by agreement between the radar method and the method of slow clock transport, which I accept, an inattentive reader might well be tempted to believe that a proof for the correct factor of retardation is also a proof of SR. However, all other theories which are a part of the examination can exhibit at least one system wherein the two methods agree - a system which could well turn out to be empirically indistinguishable from that assumed in an earthly laboratory such as that placed in Aarhus. Why were all those other possible theories not discussed, or just mentioned, in the report from the Aarhus-team?

Actually there is not much that our Aarhus-team is able to prove. Nevertheless, the courageous assertion is made that theirs is the "most accurate direct verification of time dilation to date". Quite apart from the futility of their belief to have verified anything finally, for good and ever - cf. Popper - there is every reason to question their assertion that the experiment is direct. In fact, the experiment only aims at a second order confirmation of the so-called transversal Doppler effect. It is therefore interesting to see that a similar effect can easily be inferred on the basis of some other theories not considered by Mansouri & Sexl; cf. Wegener: *PIRT-Proc.1988 & Phys.Ess.8,1994*.

A PROVISIONAL ACCEPTANCE OF SR

Let us now for amusement's sake - and despite all the above-mentioned facts - provisionally accept the formal validity of SR. From this acceptance it does not follow, as shown, that we must accept the traditional interpretation of SR. Beside the standard interpretation there is a free field comprising a great number of variations which deviate more or less from the standard interpretation of Einstein's SR. Each of these variations carries with it a concept of simultaneity which corresponds with a more or less arbitrary definition of our concept of objective existence and reality.

In this whole spectrum of possibilities, is it conceivable that there is a single one so plausible that it can obtain general consensus? With the help of some mathematical logic one can analyze the more natural definitions of the concept of existence or reality that are consistent with SR. It then turns out that this concept allow for being defined in a multitude of different ways! The most serious weakness of SR is precisely that this concept can only be made univocal by arbitrary convention.

The only alternative to this is give up to entire project and admit the total collapse of all temporal distinctions within SR. This is exactly what is done when one postulates the absolute timeless existence of a 4-dimensional space-time continuum of events. With this fiction physics implements the Einsteinian program demanding a reduction of all physical concepts to space-time geometry. Science depicts nature as a block of ice. Needless to say, such science is not only repugnant, but flatly unacceptable.

CONCLUSION

Recently returned from an international meeting on the interpretations of relativity ("Physical Interpretations of Relativity Theory", Imperial Collge, London; Sept. 1988), I can report that the orthodox understanding of these theories is evidently on retreat (6). A clear majority of the participants of the conference openly supported the idea of a privileged frame of reference in the shape of a cosmological substratum, a kind of ether. The motives differed, but many proposals stemmed from the well-known difficulties concerning the possible (or impossible?) union of relativity and quantum theory (7).

If there is a privileged frame of reference there is also a privileged universal time. If this time is not only irreversible, but can be demonstrated to represent a true flow, then it is hardly too strong to speak of a real collapse of Einstein picture of the universe. My own view of the issue is covered adequately by the following quotation:

Interviewer:

"Bell's inequality, as I understand it, is rooted in two assumptions: the first is what we might call objective reality - the reality of the external world, independent of our observations; the second is locality, or non-separability, or no faster-than-light signalling. Aspect's experiment appears to indicate that one of these two has to go. Which of the two would you .. stick to?"

John Bell:

"I think it's a deep dilemma, and the solution of it will not be trivial. It will require a substantial change in the way we look at things. But I would say that the cheapest resolution is something like going back to relativity as it was before Einstein, when people like Lorentz and Poincaré thought that there was an aether - a preferred frame of reference.

Davies & Brown, eds.: The Ghost in the Atom, Cambridge 1987.

NOTES

1. "In fact there is no experimental evidence at all for the theory; all that appears to support it does so through a circular argument" -

H. Dingle, introduction to H. Bergson: 'Duration & Simultaneity', Bobbs-Merrill 1965.

2. Bergson underpins his conclusion with the following elegant argument:

The mathematical content of SR are the so-called Lorentz transformations (*LT*), which entail that a clock in inertial motion will go at a slower rate than a clock which is permanently at rest, although both clocks count "real" seconds, and further that a rod pointing in the direction of inertial motion will appear to be shortened as compared to a rod at rest, although both rods are supposed to measure the same "real" meter. Now let two observers, each being provided with a standard clock and a standard meter, be in relative uniform motion. Abstracting from the surroundings, we are then free to decide which of the observers we will regard as being at rest and which in motion, or whether we prefer to distribute the motion equally on both observers, so that they move with equal speed in opposite directions. In the latter case everybody will agree that the equal contraction of both rods should be explained as an illusion on a par with what we observe when we see a cane as apparently broken if it is immersed half into water. Further, everybody will agree, that the shortening of the rods ceases together with the motion. Why, then, do most experts judge the situation to be altogether different when considering two clocks in relative motion? And, if the difference between the clocks can accumulate over time, as is usually claimed, why can an astronaut not return to his earthly twin in the size of a dwarf?

3. Three clocks, *P, Q, R*, are called *congruent* if they conform to the following conditions:

1) *the relation of simultaneity is reflexive* (a clock is simultaneous with itself); 2) *the relation of simultaneity is reciprocal* (if $t_P = t_Q$ then $t_Q = t_P$); 3) *the relation of simultaneity is transitive* (if both $t_P = t_Q$ and $t_Q = t_R$ then $t_P = t_R$). In case that all three conditions are met, the clocks are said to define a class of equivalence regarding simultaneity. The crucial difference between CM (classical mechanics) and SR (special relativity) now is that, according to CM, all clocks in uniform relative motion can (at least in principle) be made congruent by proper synchronization, whereas, according to SR, only those clocks which are at rest relative to each other, or those which depart with uniform speed from a common event of coincidence, can be made congruent by synchronization; so, within SR, clocks departing with uniform speed from different events of coincidence constitute different classes of equivalence, or "sprays". This is worked out in detail in a monograph written by J.W. Schutz: *Foundations of Special Relativity*, Springer NY, 1973. However, it can be asked whether there are in fact more than one equivalence class or "spray". That there is not was claimed by E.A. Milne. On this issue he would find support by all those who insist that there is only one privileged rest frame in the universe, viz. the "ether".

4. J.A. Winnie: *Philosophy of Science* 37, 81, 1970.

5. Kaivola, Poulsen & al.: Rel.Doppler-Shift, *Phys.Rev.Lett.*, Jan., 1985.

6. For my papers to the biennial *PIRT-conferences* 1988-2002, see www.relativity.me

7. Cf.e.g. I Prigogine: *From Being to Becoming*, s. 215, Freeman 1983.

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