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TIME-SPACE RATHER THAN SPACE-TIME

The Classical Space-Time

Hardly any other problem has been discussed more than that of the status of time in modern physics. This is only natural since there are not many other more important problems in philosophy of science and in philosophy in general. There are also few other areas where controversies as well as confusion were more frequent. This is true not only of popular and semi-popular expositions of the Minkowski concept of space-time but also of a number of its philosophical interpretations. Generally we do not find anything of this kind in the writings of physicists, at least as long as they confine themselves to strictly mathematical and physical expositions; but when they sometimes venture beyond a strictly mathematical approach, they often do not escape certain unconscious or semi-conscious prejudices which are contrary not only to the spirit but sometimes even to the letter of relativity. The true significance of the relativistic fusion of space and time can be understood only when we contrast it with its classical counterpart, i.e., with what may be called the Newtonian space-time. Only on such a contrasting

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background will the revolutionary meaning of the new concept clearly stand out.

The term "space-time," coined by Minkowski in 1908, probably had never been used before that date; but although the word was missing, the concept itself was present, even though, as we shall see, its meaning was altogether different from that of Minkowski. Thus Descartes called time a "dimension," d'Alembert even "the fourth dimension;" while Lagrange called mechanics "*une géométrie à quatre dimensions.*"[1] There is no question that classical science as well as classical philosophy had a definite notion about the way space and time were related; in this sense one can speak about the classical i.e., Newton-Euclidian, space-time or of the "four-dimensional space-time continuum."

Because of our psychological inability to visualize the fourth dimension, the four-dimensional continuum, whether classical or relativistic, can be symbolically represented only by three-dimensional models; only on such models can the structure of both concepts as well as their most significant differences be conveniently studied. It is true that there are certain implicit dangers in using such graphical representations, because in every geometrical diagram time appears to be misleadingly spatialized. On the other hand, such diagrams, provided we do not forget their symbolic nature, have a definite advantage of disclosing more clearly the relation of space and time in their respective synthesis, whether classical or modern. A similar procedure was successfully used when the properties of Riemannian space, which by their own nature remain non-intuitive, were illustrated by the properties of a two-dimensional spherical surface.

Now in the three-dimensional model of space-time, its spatial component is represented by a Euclidian plane, either horizontal or vertical, while "the fourth dimension of time" is symbolized by a straight line, perpendicular to this plane. All successive instantaneous spaces are represented by parallel planes, all orthogonal to the time-axis, each of which contains a state of the world history at that particular instant. In other words, each instantaneous space contains all events which are

[1] See the references in Emil Meyerson, *La déduction relativiste*, Paris, 1925. pp. 107-8.

simultaneous in the absolute sense; in truth, there is a mere terminological difference between the expression "the class of simultaneous events" and "instantaneous space." Let us recall the lucid words of Hermann Weyl: "All simultaneous world-points form a three-dimensional *stratum*, all world-points of equal location, a one-dimensional *fiber*."[2] Thus the classical space-time can be defined as a continuous succession of instantaneous spaces.

It is hardly necessary to stress how fundamental this model of space-time had been in classical physics. It underlay the concept of absolute simultaneity which was absolutely essential to the classical models of matter. In classical corpuscular-kinetic models every state of the world at each particular instant was defined as a huge instantaneous configuration of an enormous number of particles, each of which was moving according to the laws of classical mechanics while preserving its physical identity through time. World history was thus viewed as a continuous succession of such instantaneous configurations. It is obvious that without the concept of absolute simultaneity that of "instantaneous configuration" would be devoid of meaning; in truth, both concepts are nearly synonymous. I say "nearly" since the state of the world at an instant could also be defined in the sense of the field theories as a set of instantaneous field intensities; what is important is that in both models the assumption of absolute simultaneity was the same. This assumption of "Everywhere Now" seemed so natural and obvious that it was rarely stated explicitly; it was one of those tacit assumptions underlying the conceptual structure of classical theories. What was more natural than to believe that simultaneous with my present moment on the Earth there is a definite moment on Mars, Neptune, Alpha-Centauri, Andromeda nebula and even on any remote galaxy, no matter how enormous its distance may be?[3]

[2] Hermann Weyl, *Philosophy of Mathematics and Natural Science*, Princeton University Press, 1949, p. 95.

[3] Cf. Pierre Gassendi, *Syntagma philosophicum* (ed. Lugduni 1658), I, p. 224: "*quodlibet temporis momentum idem est in omnibus locis*;" Isaac Newton. *Opera*, ed. by Horsley, III, p. 72: "*unumcumque temporis indivisibile momentum ubique*." On this point cf. my article "Was Gassendi a Predecessor of Newton?" in *Proceedings of the X International Congress of History of Science*, Paris, 1964, pp. 705-9.

The concept of absolute simultaneity was also one of the most essential parts of the classical deterministic scheme. Let us recall its famous formulation by Laplace: a complete knowledge of *the present state of the world*—which in prevailing mechanistic models meant a complete knowledge of the position and velocities of *all* the particles in the universe—would make possible in principle the knowledge of all future states of the world. Technical impossibility of such prediction was irrelevant; what was important was the conviction that the present state of the universe—in truth *any* particular state—entails all its subsequent states, even their most insignificant details. The Laplacean "omniscient mind" was merely a metaphor illustrating the universal impersonal order of nature in which everything is rigorously predetermined from eternity and without any shade of ambiguity. This was stated by Democritus at the very dawn of Western thought: "By necessity are foreordained all things that were and are and are to come." Classical physics, twenty-two centuries later, expressed the same view in a more precise form by substituting the laws of Newtonian dynamics for the general term "necessity." There were difficulties in this view, as I shall try to point out; but what is important in the present context is that without the concept of objective, i.e., absolute simultaneity, the very concept of a state of the world at an instant—what Eddington later called "world-wide instant"[4]—loses its meaning. Yet, it is this concept on which the Newton-Laplacean determinism was based.

The Structure of Minkowski's World

One of the most fundamental differences between Newton-Laplacean space-time and its modern Einsteinian counterpart is that the latter cannot be defined as a succession of instantaneous spaces. In other words, in the latter it is impossible to make instantaneous cuts perpendicular to "the axis of time;" if we try to do it, we obtain different instantaneous spaces in dif-

[4] A. S. Eddington, *The Nature of the Physical World*, New York, Macmillan, 1933, p. 47.

ferent inertial systems. Using a similar three-dimensional model used before, we see at once a significant difference between the old and the new model: in the latter instead of one single orthogonal plane, representing one single instantaneous space at that particular instant, we obtain a multiplicity of such planes, inclined at different angles with respect to the time-axis. What is more important is that *none of them has any privileged status over any other*. In other words, there is no unique cosmic "Everywhere-Now," no "world-wide instant;" this is the meaning of the famous *relativization of simultaneity*. This is the term commonly used; but as such it does not convey the truly radical meaning which underlies it. A far more appropriate term is "denial of simultaneity." In Einstein's own final words: "There is no such thing as simultaneity of distant events."[5]

These words of Einstein's are apparently little known and, so far as I know, hardly ever stressed; yet they refer to the fact which becomes evident by a mere inspection of Minkowski's diagram. While in the classical diagram a single instantaneous space, symbolized by a plane surface perpendicular to the time dimension, separated at each particular moment the objectively past events from the objectively future events, the situation is quite different and far more complex in Minkowski's scheme. In it there is also an objective difference between the past and the future at each particular Here-Now event. But, unlike the classical scheme, the past is separated from the future not by a single instantaneous space but by *the whole four-dimensional region* which Eddington called "Elsewhere" and which in Minkowski's diagram is represented by a three-dimensional region lying between the conic regions of "Absolute Past" and "Absolute Future." By "Absolute Past" are designated those events which causally influence the particular Here-Now event; by "Absolute Future" those events which will be or may be influenced by the present Here-Now. This is why such events are also called "causal past" or "causal future" respectively. The conical shape of these regions is due to the limit character of the velocity of light; unlike in classical physics, no physical action can move with a velocity larger than that of electro-

[5] A. Einstein, "Autobiographical Notes," in: *Albert Einstein, Philosopher-Scientist*, ed. by Paul Schilpp, Evanston, Ill., 1949, p. 61.

magnetic waves. Consequently, the world-lines of photons lie on the surface of the cone which has its vertex in the Here-Now event and which separates the causal past from the Elsewhere region. The same is true of the forward causal cone, separating the Absolute Future from the Elsewhere region, except that we have to be on guard against taking our spatial diagram too literally; in other words, we must keep in mind that for each Here-Now future events are only *potentially real*; otherwise we would slip unwittingly into the fallacy of spatialization. (Such potentiality of the world lines can be indicated in our diagram by drawing *the dotted lines* in contrast to the fully drawn lines in the rearward cone of the past events.)

The following points should be stressed when we want to interpret the physical and—let us not be afraid of the word—*philosophical* meaning of Minkowski's time-space.

1. *Simultaneity of distant events is not only made relative but is simply denied.*

Let us recall again Einstein's *ipsissima verba.* This will be hotly denied by all those who claim that the term "simultaneity" becomes now a three-term relation: instead of speaking of simultaneity of two events as classical physics did, we must specify the inertial system in which such simultaneity occurs—and then such simultaneity can be unambiguously defined. In other words, each observer can legitimately bisect his own Elsewhere region by an instantaneous cross-section—his own instantaneous space—on which the events simultaneous with his own Here-Now are located. On this point two following remarks should be made. First, all such so-called simultaneous events are *ex definitione* unobservable since they are located in the observer's Elsewhere region from which not even the fastest signal can reach his particular Here-Now. In other words, the existence of such events is merely *stipulated*, never perceived or registered. Second, the physical entities cannot be created by a mere stipulation. Which physical meaning can be assigned to the entities, intrinsically unobservable and which, furthermore, are different in different inertial systems?[6] The attribute of "being present"

[6] Cf. M. Capek, *The Philosophical Impact of Contemporary Physics*, enlarged ed., Princeton, Van Nostrand, 1969, pp. 189-90.

is confined to each particular "Here-Now" and can never be extended beyond its limits to become "Everywhere Now." The word "present" should now be taken in its original etymological sense of *prae-esse* in both its spatial and temporal sense. Each "Here-Now" is simultaneous with itself (which, as we shall see, is not as trivial as it sounds). As A. A. Robb, an unjustly forgotten "Euclid of relativity," expressed it more than three-quarters of century ago, "the present instant properly speaking does not extend beyond itself." In other words, still his, "we cannot strictly identify the same instant in two distinct points of space."[7] Eddington expressed the same view when he dismissed the existence of the "world-wide instants;" and Whitehead when he stated that "there is no such unique present instant" at which all matter is simultaneously real.[8]

This is one of the most paradoxical results of relativity against which our Newton-Euclidian subconscious vigorously protests. As we shall see, the notion of absolute simultaneity persists in the imagination of not a few physicists and cosmologists despite their explicit verbal denials; "the notion of absolute simultaneity is so deeply ingrained in the way most people think about space-time that it even takes a great deal of effort to be consciously aware of when and how one is using this assumption."[9]

2. *Elimination of simultaneity does not mean an elimination of the successive character of the physical world.*

Unfortunately, the very opposite view is widely spread and can be found not only in popular and semi-popular expositions of relativity but not infrequently among physicists and even more among philosophers. Emile Meyerson in his book *La déduction relativiste*, which Einstein praised as one of the best philosophical interpretations of relativity, gave a long list of those who interpreted Minkowski's space-time in a static sense, as a sort

[7] A. A. Robb, *The Absolute Relations of Space and Time*, Cambridge University Press, 1921, pp. 7, 12-13.
[8] Eddington, *loc. cit.*; A. N. Whitehead, *Science and the Modern World*, New York, MacMillan, 1926, p. 172.
[9] Robert M. Wald, *Space, Time and Gravity*, Univ. of Chicago Press, 1977, p. 30.

of four-dimensional hyperspace whose fourth, so-called temporal dimension was not essentially different from the three spatial ones.[10] Even such an outstanding man as Ludwig Silberstein claimed that the theory of relativity was anticipated by H. G. Wells in his famous novel *Time Machine,* in which the fictitious inventor makes a machine on which he can ride in either direction of time, either into the past or into the future.[11] For such a traveller, time would obviously cease to exist as its "successive" phase would co-exist simultaneously, i.e., would not be successive at all. What we call "future" would really be a hidden present, an unknown territory not yet discovered but already existing prior to our discovery. Fortunately, such fantasies have not the slightest basis in the physics of relativity. Yet, the very persistence of such misinterpretations must have some deep, underlying cause which a historian of ideas can easily identify: the perennial tradition of both Western and Eastern thought which regards time as merely apparent and not genuinely real. The tendency to spatialize time is only a more concrete form of the same traditional trend. But in addition to this tradition the very fact of relativity of simultaneity is often used as an argument for a static interpretation of Minkowski's continuum as, for instance, by Kurt Gödel:

> The existence of an objective lapse of time, 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.[12]

[10] E. Meyerson, *La déduction relativiste*, pp. 97-108. Einstein's comment on Meyerson's book was published in *Revue philosophique de la France et de l'étranger* v. 105, 1908, pp. 161-66. Its English translation by Mary-Alice and David A. Sipfle was published in my anthology *The Concepts of Space and Time. Their Structure and Their Development*, Dordrecht, D. Reidel, 1976, pp. 361-367.

[11] L. Silberstein, *Theory of Relativity*, London, 1914, p. 134. Quoted by H. Bergson, *Durée et simultanéité*, Paris, 1923, p. 223.

[12] Kurt Gödel, "A Remark About the Relationship Between Relativity and Idealistic Philosophy," in *Albert Einstein: Philosopher-Scientist*, ed. by Paul Schilpp, Evanston, Ill., 1949, p. 558.

Gödel's argument sounds at first very plausible; for if there is no universal "Eyerywhere-Now," there would be no objective boundary separating the past from the future and thus the very distinction between successive phases of the universe would apparently disappear. What Gödel overlooked was the fact that in the world of Minkowski the future is separated from the past even *more effectively* than in the classical space-time as even a superficial inspection of the relativistic space-time diagram shows when we compare it to the classical diagram. While in the latter the boundary separating the future from the past is an "infinitely thin," durationless layer (i.e an instantaneous space at each particular moment), in the former it is the whole four-dimensional region of "Elsewhere" which separates them. The very existence of the Elsewhere region is a direct consequence of the limit velocity of light which may be properly called the velocity of causal propagation; as Eddington observed long ago, "the limit to the velocity of signals is our bulwark against the topsy-turvydom of past and future, of which Einstein's theory is sometimes wrongly accused."[13]

But it is precisely such "topsy-turvydom of past and future" which Gödel explicitly advocates. He is only consistent when he seriously considers the possibility of a Wellsian trip to the past —and to the future—and back to the present. (He even computes the weight of a fuel which a rocket ship would need for such a round trip!) He is equally consistent when he is aware of his intellectual kinship with Parmenides, McTaggart and the tradition of timeless idealism.[14] But he errs when he confuses the elimination of Newtonian time with an elimination of time in general. What he does not realize is that Newtonian time is only a special case of time in general in a similar sense as classical Euclidian space is merely a special instance of space or spatiality in general. To deny temporality in general because its specific Newtonian form proved to be unsatisfactory is as little justified as the claim of some Kantians that a denial of Euclidian space destroys the possibility of *any* geometry; or

[13] Eddington, *op. cit.*, pp. 57-58.
[14] K. Gödel, *loc. cit.*, pp. 558-561.

that a rejection of classical determinism excludes the possibility of *any* causation.[15]

3. *The causally related events which are successive in one frame of reference remain so in all other inertial systems.*

In other words, while the juxtaposition of events (which is just another term for their simultaneity) is fully relativized—I would prefer to say, with Einstein, denied—the succession of the events mentioned above remains *absolute*, independent of the observer; it is *topologically, though not metrically* invariant. This is one of a few absolutes preserved by relativity; in truth, it is more correct to say that this particular absolute was *discovered* by relativity, for in classical physics the situation was different. Since there was no upper limit to mechanical velocities, for an observer moving with the velocity of light world history would be standing still while an observer moving faster than light would perceive—with a sufficiently powerful telescope—the earth's history in a reversed order; to him "Waterloo would precede Austerlitz" as he would be gradually overtaking the earlier and earlier wave-fronts of light.[16] It is true that in classical physics such inversion of causal relation would be merely *apparent* because for the privileged observer, at rest with respect to absolute space, the events would appear in their true and objective order. But such a situation would be far more serious in the theory of relativity which eliminated the privileged frame of reference—*if* there were no limit to the velocity of light. But fortunately this is not so; thus because of the unattainability of the velocity of light *not even an apparent* inversion of cause and effect can ever occur.

All this follows inescapably from Minkowski's formula for the constancy of the world interval as was pointed out long ago by Paul Langevin. It would be otiose to restate it again in a specific mathematical form.[17] It may be summed up in the

[15] On this problem cf. my articles "The Doctrine of Necessity Re-examined," *The Review of Metaphysics* V, 1951, pp. 11-44; "Toward a Widening of the Notion of Causality", *Diogenes* No. 28, Winter, 1959, pp. 63-90.

[16] This possibility was envisaged, for instance, by Flammarion as recalled by H. Poincaré in his *La science et la méthode*, Paris, 1909, Ch. 4.

[17] Paul Langevin, "Le temps, l'espace et la causalité dans la physique moderne," *Bulletin de la Société française de la philosophie*, Séance du 19 octobre 1911;

following way: the sequence of the events whose spatial separation is smaller than their separation in time multiplied by the velocity of light—in other words, the temporal order of causally related events—can never degenerate into simultaneity by any choice of the frame of reference; *a fortiori* it can never be inverted. In the usual language of relativity, their time separation is *absolute*. In this respect the temporal order of such events is basically different from that of causally unrelated events which Hans Reichenbach appropriately called "unreal temporal sequences" (*die irreellen Zeitfolgen*)[18] whose inversion can be obtained by a convenient change to a different referential system. Reichenbach's term is especially well chosen since it indicates their unreal fictitious character. Their status is purely conceptual, comparable to the status of simultaneity of distant events; no world lines, no concrete physical connections correspond either to "unreal sequences" or to "simultaneity lines." This is obvious from Minkowski's space-time diagram: both the simultaneity lines and unreal sequences lie in the Elsewhere region, *causally not interacting* with the Here-Now.

It is thus clear that the relativistic space-time—whose more appropriate name should be time-space—consists of a network of the causal line ("world-lines") *whose successive, irreversible character is absolute*, i.e independent of any choice of the frame of reference. Such time-space is obviously *toto coelo* different from the static, becomingless hyperspace which exists more in the imagination of some philosophers than in the thought of physicists.

The Physical Unreality of the Future

The reality of succession and the unreality (or "virtuality") of the future are logically correlated terms; one cannot have one without the other. Conversely, a denial of succession always went hand in hand with the view that the future is *somehow real*, even though still hidden to our consciousness which remains

"L'evolution de l'espace et du temps," *Revue de métaphysique et de morale*, vol. XIX, 1911, pp. 455-466; also in *Scientia*, vol. X, 1911, pp. 31-54.

[18] Hans Reichenbach, *Die Philosophie der Raum-Zeit Lehre*, Berlin, 1928, p. 175.

blindfolded by the illusion of time which prevents it from perceiving what timelessly exists and what only human ignorance calls "future." Historical examples abound and to mention all of them would mean to give a survey of the whole history of Western thought from Parmenides to Bradley; the contemporary doctrine of "the mind dependence of becoming" is its last version. Thus the temptation to interpret Minkowski's diagram in the terms of the time-honored Eleatic tradition was naturally very strong. But it can be convincingly shown by attentively analyzing Minkowski's formula and his space-time diagram that no verifiable physical reality corresponds to future events; in other words, that the future is *physically empty*.[19]

One important distinction is not infrequently overlooked and rarely stressed explicitly, yet without it confusions cannot be avoided. It is the distinction between *nominally "future" events* and the genuine future. To the first category belong the events whose relations to my "Here-Now" are temporally indeterminate since they belong neither to my absolute past nor to my absolute future. Such events are *declared* to be future if they lie on the forward side of my "now line" by which I arbitrarily divide my own region of Elsewhere (which could also be called "Elsewhen"). Another observer, who shares with me my "Here Now," but belongs to an inertial system different from mine, will draw a different "now line;" to him the events which I regard as future, will appear as either simultaneous or in his non-causal past. (We should not really use the term "appear" since *all* events in Elsewhere are not only never perceived but are *unperceivable in principle*.) On the other hand there is the *authentic* future—my own *causal* and *absolute* future, symbolized by the forward cone radiating from my Here-Now. Its absolute character follows immediately from Minkowski's formula for the constancy of the world interval which entails the irreversibility of the temporal order of causally connected events.

For consider any event in my causal future; it is (more accurately: it *will* be) a causal successor of the event Here-Now and in this sense it will occur *after* my own experienced present.

[19] I dealt with this problem most recently in the article "Relativity and the Status of Becoming," *Foundations of Physics*, vol. IV, December, 1975, in particular in its last part "The Physical Emptiness of the Future." (pp. 610-17).

(My own perception and, more generally, my own psychological present is irrelevant since even a "merely physical" Here-Now event will exhibit the same relationship to its own causal future). This means that not only can I not perceive any event on my own future world-line, *but neither can I perceive any event on that segment of any other world-line different from mine which is included in my own causal future.* For the necessary condition for the observability of any event is its inclusion in the causal past of the observer in question. No event in my causal future can affect my Here-Now for the simple reason that my own causal past and causal future do not overlap. This conclusion is so truistic that it may sound silly—until we remember the persistence of "time-tunnel" fantasies about the round trips to the past, the "messages" from the future, etc.

But could my future events perhaps be perceived by the observers located on some world lines which are far enough from my present Here-Now? Such hypothetical observers can be divided into three classes: a) those included in my own causal past; b) those in my own Elsewhere region and, finally; c) those who belong to my causal future. As we are going to show, my own absolute future remains unobservable in principle *in all these three cases.* The group a) is automatically excluded by the fact that no signal can be sent to the past. For in the light of Minkowski's diagram my Here-Now—and *a fortiori* my absolute future—are included in the absolute future of all my causal predecessors; no signal can reach them from my own Here-Now—*a fortiori* none from any event in my absolute future. "We cannot send wire messages into the past," as Einstein observed long ago.[20] For common sense this is obvious; but it is known that that is not always a reliable judge, as the whole development of modern physics shows. But in this particular case the conclusion of common sense coincides with that of Einstein.

One will reach the same conclusion in considering a hypothetical observer in the Elsewhere region. By the very definition of this region, no causal influence, no signal coming from my Here-Now, can reach him. If, *per impossibile*, he should receive a message from my causal future *before* the signal coming from

[20] Quoted by Meyerson, *op. cit.*, p. 104.

my present Here-Now, he would perceive the causally related events in a *reversed temporal order* in contradiction to Minkowski's formula. The impossibility of such a situation follows immediately from Minkowski's diagram: every signal coming either from my present Here-Now or from my absolute future could reach an observer in Elsewhere only by the velocity greater than that of light in violation of the basic principle of relativity.

There remains the third class of hypothetical observers—those who belong to my absolute future. Common sense and the majority of scientists will dismiss the very idea of "future observers" as a self-contradictory fiction: are not "future observers" unreal by their very definition? But, as mentioned above, one must be on guard against deceptive intuitive certainties of traditional common sense; this is why those thoroughly acquainted with relativity will prefer to stress an *intrinsically unobservable*, i.e. *counter-empirical* character of the notion of "future frame of reference." *All* events in my causal future are intrinsically unobservable since they are not included in the causal past of my Here-Now; and this is obviously true of everything happening to hypothetical future observers. Thus the notion of observability by the observers who themselves are intrinsically unobservable remains meaningless physically as well as philosophically.

This conclusion is hotly challenged—it is true more by some philosophers than by physicists—by the counter-arguments which have a plausible relativistic ring. They do not deny that every particular Here-Now event divides unambiguously its absolute (causal) past from its absolute (causal) future. Neither would they deny (though they hardly ever stress it) that the events in absolute future are intrinsically unobservable for that particular Here-Now present. But they point out that this is true of *every* present and since the basic idea of relativity is the equivalence of *all* frames of reference, the very concept of Here-Now is relativized, which also means a relativization of the dividing line between the past and the future. To single out any particular present as absolute is contrary to the principle of relativity which denies the existence of any privileged frame of reference. There is an infinite number of different "Here-Nows" and, consequently, an infinite number of different ways to

separate the past from the future; my own particular "Here-Now" is as relative as any other. Furthermore, it is continually shifting and its very movement makes its choice arbitrary. All individual Here-Nows are equivalent and in this sense equally real.[21] Another argument for a static interpretation of Minkowski's world. We would be back to Parmenides!

Let me omit the historical reasons, already mentioned, which make this view thoroughly suspect. More important are the following reasons: a) If by "relativity of the present" is meant the fact that it is non-stationary, there is no real disagreement; for the present moment is by its very nature transitory, "perishing," as Whitehead said, and to say that something is passing is another way of saying that something *becomes* something else, that becoming is real. It is another argument for the dynamic nature of space-time as the supersession of the present by its causal successor is the very essence of becoming. b) If by "relativization of Here-Now" is meant the fact that there will be a future Here-Now which will include in its causal past my own present event, then again there is no disagreement; it is obvious that the events in 1984 will be influenced by my present Here-Now. It is equally obvious that the events in 1984 will be witnessed by the observers at that time; but then the whole thesis is reduced to a harmless truism that "future events will be observed in future frames of reference." But the disagreement begins as soon as we replace the future tense "will be observed" by the tenseless "*is* observed." If the latter is understood in the timeless Eleatic sense, then all frames of reference, including those now in the future would be, indeed, on equal footing, being all "equally real." But they cannot be.

For the word "arbitrary" applied to the present "Here-Now"

[21] This argument was put forth by Hugo Bergman, *Der Kampf um das Kausalgesetz in der jüngsten Physik*, Braunschweig, 1929, pp. 25-28. This argument was adopted by A. Grünbaum, *Philosophical Problems of Space and Time*, New York, 1963 and *Modern Science and Zeno's Paradoxes*, Wesleyan Univ. Press, 1967, Ch. I. My answer to Grünbaum is in "The Myth of Frozen Passage" in *Boston Studies in the Philosophy of Science*, II, 1965, pp. 441-453 and "Relativity and the Status of Becoming," *Foundations of Physics* V, 1975, pp. 607-616. Some other defenders of the static interpretation of Minkowski's world ignore the basic difference between Newtonian and Einsteinian spacetime; for instance Donald Williams "The Myth of Frozen Passage" *Journal of Philosophy*, v. 40, 1951, p. 457 and W. Quine in his *Word and Object*, Cambridge, Mass., 1967, p. 160.

is certainly out of place. For my present living "now" is unescapable and in this sense *absolute*; as Hans Reichenbach pointed out, in reformulating, perhaps unwittingly, the Cartesian *Cogito* in a dynamic, temporalistic sense, the very act by which we deny it reasserts it:

> Un acte de pensée est un événement et définit donc une position dans le temps. Si mes expériences se produisent toujours dans le cadre d'un "maintenant" cela veut dire que chaque acte de pensée définit un point de référence. Nous ne pouvons pas échapper au "maintenant" parce que la tentative d'y échapper signifie un acte de pensée et donc définit un "maintenant." Une pensée sans un point de référence n'existe pas, parce que la pensée elle-même le définit.[22]

It is certainly significant that Reichenbach, who warned against the spatialization of time in his earlier writings,[23] reasserted so definitely the reality of becoming in one of his last articles. In truth, what he asserted in the passage quoted above is hardly denied by the opponents who nevertheless insist that while "Now" is *psychologically* real, it neverthless does not have any *physical* status.[24] Yet, we are certainly living in the twentieth century, more specifically in the year 1983; is it possible to claim with any degree of seriousness that such statements are devoid of any physical meaning? We are certainly not living in the Cretacious period nor in the time of the Norman invasion, nor are we living in the year 2000. My present living is certainly not merely psychological since it is roughly co-extensive with the present physical state of the Earth.

The doctrine of "mind dependence of becoming" which denies any objective status to Here-Now in excluding becoming

[22] H. Reichenbach, "Les fondements logiques de la mécanique des quanta," *Annales de l'Institut Henri Poincaré*, v. XIII, 1952, p. 157.

[23] H. Reichenbach, "Die Kausalstruktur der Welt und der Unterschied Vergangenheit und Zukunft," *Sitzungsberichte der math.-naturw. Abteilung der bayerischen Akademie der Wissenschaften*, Munich, 1924, pp. 133-175. Also *The Philosophy of Space and Time*, Dover Publ., 1958, esp. § 16, "The Difference between Space and Time" and § 43, "The Singular Nature of Time."

[24] H. Bergmann, *op. cit.*, p. 25: "Darum hat dieser rein subjektive Begriff der Jetz, der Gegenwart, in der Physik keine Stelle." Against Bergmann's view cf. G. J. Whitrow, *The Natural Philosophy of Time*, 2nd ed., Oxford, 1980, pp. 348-350.

from the physical world and confining it in a subjective, mental realm, advocates, probably unwittingly, a far more radical kind of dualism than the traditional Cartesian dualism. Its intrinsic difficulties are, consequently, far more serious. In Descartes' "bifurcation of nature" the physical and mental realms, despite their heterogeneity, shared at least one important feature: *the temporal character.* The physical as well as the mental events occur in time. In the new dualism they do not share even this single feature: on one side there is the physical four-dimensional world devoid of change as its so-called temporal dimension is, in virtue of its static character, a thinly disguised spatial distance; on the other side, there is the mental world into which change is confined. No intelligible relation or interaction between such radically heterogeneous regions is conceivable. At the same time, there is a strange ambiguity inherent in this doctrine. By its insistence on the static, timeless character of the objective world, it has an affinity with idealism which Kurt Gödel, for instance, admits quite openly; on the other hand, by claiming that the objective world is physical, it tends toward materialism which, for instance, J. J. Smart explicitly accepts. This ambiguity was already inherent in the first historical version of this theory—in the thought of Parmenides—and thus it is hardly surprising that there are similar hesitancies in the revived Eleatism of the twentieth century. Among those who are clearly aware of the dualistic character of this doctrine is M. Olivier Costa de Beauregard when he writes:

> Whitehead et M. Čapek parlent à ce sujet d'une avance créatrice de la nature. Le lecteur voit en quel sense nous n'adhérons pas à cette vue: *L'avance de Whitehead est écrite dans l'espace-temps, et en tant qu'avance* (pour nous), *et en tant que créatrice.* De la *matière seule*, qui est statiquement déployée dans l'espace-temps, on ne peut pas dire qu'elle avance; si donc on prononce le mot d'avance, et même d'*avance créatrice, c'est que la Nature dont on parle ne se réduit pas à la matière.* (Author's italics.)[25]

In other words, the author of this passage regards the allegedly static character of space-time as an *argument for dualism*; the

[25] Olivier Costa de Beauregard, *Le second principe de la science du temps*, Paris, Editions du Seuil, 1963, p. 132.

reality of becoming within the mental realm shows that not everything is reducible to matter. On the other hand, other thinkers leaning toward materialism such as, for instance, Mario Bunge, dismiss the static interpretation of space-time (without naming any of its representatives) contemptuously.[26] Such diverse reactions toward the Neo-Eleatic doctrine are due to its metaphysical ambiguity: it can be interpreted idealistically or physicalistically or dualistically. But all these interpretations have one postulate in common: that "the true reality exists unchangingly," or, as Bergson put it lucidly, "the totality of the real is postulated complete in eternity." In such a view "the apparent duration of things expresses merely the infirmity of a mind that cannot know everything at once."[27] But if succession is a mere "infirmity" or "illusion" of mind, the existence of "mind" or "mental realm" is tacitly assumed—and this makes the position of materialists or, as they prefer to be called today, physicalists, especially difficult. For idealists such as Bradley, or McTaggart, or Kurt Gödel, the alleged illusion of succession has at least a certain *locus* since it exists in the subjective realm. The physicalistic Neo-Eleatics, however, deny such realm or—what is the same—reduce it to the brain, i.e., to a part of the physical, in their view, becomingless, world; consequently, in their view, even the very *illusion* or *appearance* of becoming is impossible! They literally cut a branch on which they are sitting. The Neo-Eleatism of idealists or of Costa de Beauregard is strange because it leads to an irrational and needless bifurcation

[26] Mario Bunge, *Foundations of Physics*, New York, Springer Verlag, 1967, p. 206: "It is often claimed that SR [Special Relativity] has wiped out the difference between space and time and even between what has been and what may be: that it has spatialized time and that it pictures the world as a block given once and for all, so that nothing ever happens: everything would exist already in some region of the Minkowski space, which would be thoroughly homogeneous and isotropic. This is preposterous. SR cannot be even stated without the notion e.m. signal, and even e.m. signal is a process (sequence of events), not a static being."

[27] H. Bergson, *Creative Evolution*, tr. by A. Mitchell, New York, 1911, p. 45. The usual, uncritically accepted claim that Bergson "completely misunderstood relativity," has been recently challenged by Marie-Antoinette Tonnélat, *Histoire du principe de relativité*, Paris, 1971, p. 280-93; M. Capek, *Bergson and Modern Physics*, Dordrecht, 1971, esp. pp. 237-256; the same author "Ce qui est vivant et ce qui est mort dans la critique bergsonienne de la relativité," *Revue de Synthèse*, 1980, pp. 313-344.

of nature; the Neo-Eleatism of materialists is not only strange but also self-contradictory.

To sum up: all that was said before leads inescapably to one definite conclusion: the physics of relativity *does not eliminate* becoming. The allegedly existing—or pre-existing—future events are nothing but gratuitous and artificial constructions, intrinsically unobservable, inspired by an unconscious—and very ancient—metaphysics; they are as useless as other discarded and unobservable entities such as phlogiston, caloric, aether etc. This is why the term "time-space" is far more appropriate than "space-time" or "four-space." The last one is especially misleading.

The present trends in cosmology, in particular the theory of the expanding universe, is an additional indication of the fact that it is space which is incorporated into becoming rather than *vice versa*. But this would require another extensive analysis which would much increase the dimensions of this article.

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