Kant, Gödel and Relativity[1]

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Abstract

Since the onset of logical positivism, the general wisdom of the philosophy of science has it that the kantian philosophy of (space and) time has been superseded by the theory of relativity, in the same sense in which the latter has replaced Newton's theory of absolute space and time. On the wake of Cassirer and Gödel, in this paper I raise doubts on this commonplace. I first suggest some conditions that are necessary to defend the ideality of time in the sense of Kant, and I then bring to bear some contemporary physical theories on such conditions.

1 What is "the problem of time"?

Time is absolutely central in our inner experience, but at least since the foundation of modern physics, it also plays an important role in the description of the outer world. To the extent that there is a *physical* and a *mental* time, one can safely surmise that the problem of trying to establish whether and how they are related is one of the most fundamental issues in the philosophy of time. Are physical and mental time in conflict, or we can regard the former as some sort of appropriate extension to the outer world of the main features of the latter?

These questions, important as they are, already presuppose, however, that there are *two* sides of the problem, namely that *there is*, at a fundamental level of description, *a physical time*. Even independently of current physical speculations on the possibility that, within a quantum theory of gravity, spacetime could become a derived or an emergent notion, philosophers should ask questions that presuppose as little as possible preconceived answers. And given that the

quintessential philosophical problem involves *what there is*, I take it that the main philosophical "problem of time" still involves a question that is at least as old as Aristotle, and that was clearly formulated by Kant:

Q_0: is time a subjective, purely ideal notion – *transcendental* in the sense of Kant – or is it rather part of the mind-independent, physical furniture of the universe?[2]

In order to try to set the conceptual stage to begin answering this question, the paper is structured as follows: §2 offers some motivations as to why I take that Q_0 just *is* the crux of the matter in the philosophy of time. With no pretense of scholarly faithfulness to the original texts, §3 offers an interpretive sketch of Kant's views of time, in such a way as to distillate *three conditions* that are *together necessary* for the ideality of time in Kant's sense: (i) time must be *non-substantial*, and the resulting relationism must be constructed in such a way that both (ii) the difference between past and future and that (iii) between earlier and later than, must be *mind-dependent*. Following Gödel (1949), §4 and §5 bring to bear the special theory of relativity on (ii) and (iii).[3]

2 Time as the criterion of concrete existence and as *principium individuationis*: the neglect of Kant

Considering the complexity of the matter, it is not unwise to begin by reminding ourselves of humdrum, familiar truths, that seem, however, to have escaped our attention entirely. Despite the fact that in ordinary language we sometime say that 'we feel the passage of time', or that 'time flies', time by itself, even more than space, appears to common sense as a "non-object" or a "non-entity". Since the space and time of our experience look as though they are devoid of any perceivable qualities in the ordinary sense, it would seem legitimate to conclude that they are also devoid of any causal power. Given that the *properties* of objects or events can be identified with *their causal powers*, time has no causal power because it appear to have no properties. However, if time and space are causally inert, why can't we regard them as mere *nothing*, in the same sense in which empty space was, for the ancient atomists, the only instance of the parmenideian notion of "nothingness"?

There appears to be at least *two* important reasons to reply to the above question in the *negative*. The first is that time, together with space, is one of the main criteria for the reality of a *concrete* object or event, *physical or mental* as it may be. Except for the question of the existence of numbers – which, platonistically, could involve real but non spatiotemporally extended, *abstract entities* – one can quite plausibly claim that a non-abstract entity *x* is real just in case *x* occupies a portion of space and time, i.e., just in case *x is in spacetime*. The second, related reason, is given by the fact that space and time yield a *principle of individuation*. While space distinguishes and separates physical objects and events that co-exist or exist at the same time, time is used to distinguish states or events belonging to the same substance, remaining in the same place or moving across space (see Howard 1997). In this sense, space and time, to use an expression that Auyang restricted to space, are "kind of dividers" (1995, 129): exactly as separation is space is regarded as sufficient to regard two *objects* as being *numerically* distinct, despite a perfect resemblance or even a *qualitative* identity as in quantum particles, separation in time is a necessary, individuating characteristic of *events*. It is not by chance that this conceptual aspect is reflected in some (pre-relativistic) theories of events, in which the Newtonian time of their occurrence is regarded as part of their definition, together with a substance and a property (see, for instance, Kim 1976).[4]

Keeping in mind these remarks, two rather striking questions naturally come to mind:

Q_1: If time (together with space) were a non-entity (unreal), how could it yield the most important criterion of the reality of things and events? Shouldn't this criterion imply, by itself, that time *is*, in some sense, real?

Q_2: How can we explain the fact that objects and events are objectively "separated" by space and time without also assuming that the latter, in some sense exist, either as "carrier" of the spatiotemporal relations in empty space, or as real, mind-independent relations exemplified by physical entities?

To my knowledge, questions like these have been neglected by the non-negligible, current philosophical literature on time: Nerlich (1994), who deserves the credit to have first raised Q_1 with respect to space, has unfortunately restricted his attention only to the latter. And since the inseparability of space and time implied by relativity is clearly not sufficient for the indistinguishability or even the identity of their properties, we must pay due attention to time.

As a first, tentative answer, we could follow a suggestion to be found in Kant's *Critique of Pure Reason*: couldn't it be that time, together with space, is an *priori* intuition that sentient beings like ourselves necessarily (transcendentally) *presuppose* to organize and structure the sensation of the external and the internal world? Note that this suggestion would explain, at least *prima facie*, both why we presuppose time in every possible experience, internal and external, and why the spatio-temporal relations yielded by the transcendental subject – to which in the following I will just refer by the expression "the mind"[5] – provide structure and order (*the pure forms*) to our sensations. In this way, any concrete phenomenon, not matter how conceptualized in terms of the categories or concepts (substance or event, state or process), *always appear to be in space and time*. In sum, in order to provide an answer to Q_1 and Q_2, *prima facie* there is no need to assume that time is a mind-independent property of the physical universe.

It is interesting to note that with the notable exception of Ernst Cassirer (1920) and Kurt Gödel (1949) – who had claimed that the theory of relativity is a striking *confirmation* of Kant's claim that time is ideal[6] – virtually no philosopher in our century has tried to rely on a kantian explanation for these puzzling questions.[7] Quite on the contrary, the general wisdom of contemporary philosophy of science has it that the kantian philosophy of time has been superseded by the theory of relativity, in the same sense in which the latter has replaced Newton's theory of absolute space and time. With respect to time, in particular, we are told that since any global separation between past and future events can no longer be regarded as *absolute*– i.e., as independent, as Kant still thought, of particular inertial reference systems or matter distribution – Kant's doctrine of time must be abandoned.

In a word, relying on the widespread claim that Kant's *Critique of Pure reason* was profoundly influenced by Newton's doctrine of *absolute* space and time as formulated in the *Principia*, the great majority of the philosophers of science of our century has simply ignored the possibility that an important aspect of Kant's *philosophical theory* of space and time – that advocating their transcendental nature – could be rescued from the abandonment of Newton's *physical theory* of absolute space and time. As evidence that at least Gödel's view on this subject differed from the received cliché, the following passage taken from an unpublished manuscript deserves being quoted: "the agreement described between certain consequences of modern physics and a doctrine that Kant set up 150 years ago in contradiction both to common sense and to the physicists and philosophers of his time, is greatly surprising, and it is hard to understand why so little attention is being paid to it in philosophical discussion of relativity theory" (Gödel 1990, vol. 2, p. 236).[8]

Obviously, philosophers that are possessed by the demon of realism would look at the two questions above from an opposite perspective. That time and space cannot exist in the same sense in which objects and event exist is clear from the simple remark that it does not make sense to say that spacetime *is* in spacetime. If localizability in spacetime is the rule by which we establish the existence of something, we cannot apply the rule to spacetime itself, for reasons that are even stronger than those that are usually presupposed by the claim that the standard meter in Paris is *not* one meter long. However, couldn't one grant that time exists *unlike* any ordinary object, and yet reject the kantian view, according to which time and space are "characteristics not inherent in the things in themselves, but only in their relation to our sensibility" (Kant 1783, 284)?

3 Three logically independent senses in which time can be said to be real

In order to explore in more detail the plausibility of rejecting the kantian explanations of Q_1 and Q_2, let us clarify why Kant's philosophy of time implies, *in modern parlance*, the mind-dependence of time. After all, it could be objected that Gödel's attribution to Kant of the claim that "time is ideal" is quite illegitimate. Especially in view of the famous distinction between phenomena and noumena, it could be replied that, according to Kant, time is unreal only insofar as it is referred to the noumena, or to the things in themselves, which are neither in space nor in time, but that, whenever it is referred to the world of phenomena, it is *real*. Isn't this the essential meaning of the famous kantian view according to which "*time is empirically real but transcendentally ideal*"?[9]

Despite the undeniable fact that our current philosophical terminology can be superposed only partially with Kant's, I take it as uncontroversial that to the extent that it is a pure intuition, and is therefore *an a priori form* of our sensations and observations, time for Kant cannot be regarded as existing in a mind-independent way ("time, apart from the subject, is nothing in itself"). *To the extent that Kant's noumenal world can be identified, following Gödel, with whatever goes beyond the directly observable entities* – a world that, going beyond the phenomena, according to van Fraassen (1980) is and will remain forever inaccessible to our knowledge – the thesis that time is "transcendentally ideal" can have (at least) *three* related, "modern" interpretations:

(a) it may mean that time (i.e., spacetime) does *not* exist over and above physical entities, in particular those that are required to measure distances and temporal intervals.

(b) supposing that such a relationism is true, it may mean that any statement containing temporal relations referred to unobservable physical entities in van Fraassen's sense is reducible to *relations* between non-spatiotemporal, purely *physical* properties of events. If time can be "defined away", and it is therefore not a fundamental ingredient of the world as described by theoretical physics, we would have a situation like the one that is hypothesized, say, by

the yet-to-be-built quantum theory of gravity, in which time is a purely "derived", "emergent" entity;

(c) it may mean that time as presupposed by theoretical physical models *cannot* be accounted for in terms of possible experiences of observers. In this case, *the time of our experience* can not be referred to the physical world at all, simply because it is *incompatible* with time as is conceived, say, within spacetime physics.

Clearly, the claim expressed in (a) is denied by a realist about time and spacetime: if time, regarded as the temporal aspect of spacetime, exists as a theoretical entity, then it exists over and above – i.e., independently of – the observable events and things located in it, *and therefore, in particular, independently of the knowing subject*. In this case, not only could the reductionist program not be completed, but what matters more, Kant's theory of time would be simply *false*, in the same sense in which Kant himself took the Newtonian thesis of the "existence of time as independent of anything external" as being incompatible with his view.

As for (b), which presupposes the truth of (a), it should be regarded as a condition of coherence of any mind-dependent, kantian view of time: any difference in our experience must be accounted by a difference in the objective world: as Weyl used to say quoting Helmholtz, "a difference in the given perceptions always rests upon real conditions". In our case, the postulated, theoretical physical world, which we (somewhat arbitrarily) identify with the noumenal world, must contain *something* that is capable of giving rise to our experience of time, *via* the encounter of the physical world with our sensibility. This something could, for instance, be *causation*, physicalistically described.[10] For our purposes, it is not necessary to go into details in this context, which could be extremely relevant for the emergence of time in quantum gravity; let it suffice to say that if a kantian program were to succeed, such a relation of causation should be characterizable in wholly non-temporal terms.

However, while substantivalism alone would be sufficient to reject Kant's philosophy of time (a possibility that Gödel did not consider), relationism by itself would not suffice to confirm it: Kant was no relationist either. In fact, even if we granted the relationist that time (spacetime) has no independent, substantial existence, but just amounts to certain temporal *relations* exemplified by physical entities of some sort, what matters more to evaluate Kant's theory of time is the issue whether such temporal relations, whatever they are, *are exemplified by physical events independently of observers*. This latter issue, in its turn, is tantamount to asking *whether the discriminations of the time of our experience can be coherently attributed to the physical world as described by our best spacetime theories*.

Clearly, such an issue calls into play the question raised in (c) above, which here will be given central emphasis, given that they also correspond to the way in which Gödel viewed the relationship between relativity theory and kantian philosophy. He was in fact convinced that Kant was too skeptical about the possibility of getting to know the things in themselves, and thought that Einstein's

contribution to physics had to be regarded as evidence that we have somehow been capable of throwing a partial glance at the noumenal world (see Wang 1995, 222). However, Gödel could argue in favor of some sort of progress in our knowledge of the noumenal world only to the extent that the time of our experience *cannot* be applied to the physical universe. Not by chance, Gödel's only quotation of Kant is directed at exactly this point "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, ad therefore also of change, would not occur at all" (Gödel 1949, p.558).[11] Gödel's claim – to be evaluated in the following – according to which the time of our experience cannot be accommodated by Einstein's theory of relativity becomes then of paramount importance, since assumes a whole new dimension in the theory of knowledge. If my reading of Gödel is correct, such a claim becomes in fact a suggestive piece of evidence that Einstein's theory of relativity helped us to peek behind the veil of Maya of phenomena, and that such an overcoming of the bounds of our senses are indeed possible!

One way to gather evidence about the objectivity of the temporal discriminations of our experience ("those affections which we represent ourselves as changes") is to look at the way *we speak about time*. As the analytic philosophy of time of our century has made abundantly clear, there are in fact *two ways* of distinguishing events in time, the tenseless way of "earlier and later than", giving us the changeless order of *succession*, and the *tensed* way of past, present and future, giving us *transition and passage*. The former way calls into question the mind-dependence of the distinction between earlier and later, and therefore not only its reducibility to *asymmetrical physical processes* but, more in general, the vexed issued of the origin and nature of *de facto* irreversible physical processes (the so-called "arrow of time"). The latter way, by involving the issue of the privileged existence of a particular instant of time, the present, which in our experience seems to separate the fixity of the past from the openness of the future – calls into play the vexed problem of the objectivity of temporal becoming, that is, *the question whether the coming into existence at any instant of time of previously future facts and events is mind-dependent*.

Considering the by-now widely agreed-upon untranslatability of tenseless talk into tensed talk[12], the thesis of the reality of time is then reduced to *three logically independent issues, namely the possibility of a substantial spacetime, the mind-independence of the distinction between earlier and later and the objectivity of the distinction between past, present and future.* Here it is important to remark that a discussion of the second and the third issue is required by the fact that Kant does not just deny the objectivity of time and space in themselves (i.e., their substantiality): this, as Gödel noted in his manuscript B2 (1990, 238) had already been accomplished by Leibniz. The true kantian achievement, which in our century has been downplayed by every philosopher of space and time except Cassirer and Gödel, consists in the denial that temporal (and spatial) relations exists objectively, that is, that they are mind-independent.[13]

Apart from the issue of substantival versus relational time (spacetime) in the general theory of relativity – which here cannot be discussed[14] – I claim that we should regard time as transcendental *only if both* the distinction between earlier than and later than *and* that between past, present and future[15] is mind-dependent. Now, while the latter distinction is usually regarded as mind-dependent, the former typically isn't,[16] something which makes the thesis of the mind-dependence of time (the kantian view of time) particularly *strong*, since it implies that also the distinction between the two "directions" of time is relative to a temporal bias introduced by observers (see Price 1996). Furthermore, it should also be noted that although the reality of becoming would somehow affect the problem of the direction of time, the mind-dependence of the A series alone does not suffice to establish that time is ideal. It is in fact logically possible to regard the future as real as the past – thereby denying becoming – while claiming that time is "asymmetric" because of the existence of *de facto* or nomologically irreversible processes. However, the distinction between past present and future is so essential to our experience that we discovered that the special theory of relativity cannot in principle represent it, Kant's theory of time would receive a significant confirmation by modern physics in the sense conveyed by (c) above.

4. The "now" and Minkowski spacetime

In what follows, I will assume that trying to establish whether the distinction between past, present and future has an objective, physical counterpart – and is therefore *mind-independent* – means trying to establish whether such a distinction is *definable* in terms of *invariant* structure of Minkowski spacetime as is standardly presented in physics textbooks.

Such a choice appears preferable for two reasons. The first is given by the fact that the requirement of definability in terms of invariant relations ensures that the candidate becoming relation be invariant for all possible observers. In our context, such invariance suffices to ensure the intersubjective validity of the becoming relation, something that should be required by any theory of objective becoming. The second reason is given by the remark that attempts at introducing additional structure in Minkowski spacetime, as in Rakic (1997), essentially amount to change the physical theory only in order to make it compatible with one's pet metaphysical hypothesis. Such a move should be resisted because, given a sufficient amount of tinkering with a physical theory – even if, as in Rakic's case, the tinkering consists in the addition of empirically superfluous structure which does not lead to any contradiction with the known phenomena – one can make a physical theory compatible with *any* metaphysical hypothesis. In this case, however, it is clear that the project of studying the compatibility between the time of our experience and the time of physics would be *trivialized*.

Our task is rather to find a geometrical structure *S* within Minkowski spacetime with respect to which one *could make* the distinction between what is already definite and fixed (the present and perhaps the past) and what is open (the future) required by objective becoming. Such an *S* should in any case be regarded

as a merely *necessary condition* for the existence of a distinction between the actual (the present) and the merely possible (the future), with the tacit understanding that a physical theory cannot be deemed capable *in principle* to explain what the coming into being in the present required by becoming really amounts to. Clearly, *it is not physics' business to tell us which instant of time is present*, and this remarks holds for Newtonian spacetime as well as for relativity. However, if the postulation of *S* were to lead to inconsistencies with the structure of Minkowski spacetime, we would have discovered an inconsistency between the time of experience and the time of relativity theory, a fact that would lend support to Kant's view of time.

In a recent paper read at the PSA98 meeting, Savitt has produced new and cogent arguments against the claim that the notion of "the present", as it is commonly understood in our experience of time, can be implemented in Minkowski spacetime (Savitt 1998). While in our experience only what occurs in the present properly speaking exists – let us call this view *presentism*, tensely or tenselessly construed – for Savitt "there is no time like the present" in Minkowski spacetime, because there is no geometrical structure capable of capturing the relevant metaphysical intuitions.

Savitt considers various options that have been proposed in the literature, among which (1) the single spatiotemporal point or the "here-now" (Stein 1991), (2) events *on* (not in) the backward light cone (Godfrey-Smith 1979), (3) the spacelike-related region with respect to a point (Weingard 1972) and (4) the set of events that are orthogonal to the world line of an inertial observer (an hyperplane of simultaneity) (Putnam 1967). He finds counterintuitive features with each of these proposals, like the *non-achronality* of the second and the third option,[17] or the *arbitrariness* of choosing between one "here-now" over another for option (1), or between two different hypersurfaces of simultaneity *relative to* two observers in *different* inertial frames for option (4). Which of the two points or the two hypersurfaces is the bearer of reality in a theory that, like Einstein's relativity, does not consider any single "perspective" as privileged?[18] As to (1), if it is understood as implying that each event is real from its own perspective but no event is privileged, it is hard to tell the difference between this "pluralistic solipsism", as Stein called it (1968), and the view that all events are real, except that in the latter view, *any* event is real as of *any* other event, while in the former, reality functions as an indexical like in Lewis' indexical theory of actuality for possible worlds.

Shouldn't we conclude that a kantian view of the distinction between past and future is confirmed, as Gödel had it, by the special theory of relativity? Before yielding to this verdict, let us give the realist about becoming the right to reply. Her best strategy may consist in trying to account for our experience of time by using the physical principles embodied in Minkowski spacetime. By making due allowance to the necessary idealization that is always present in any physical model, the most obvious choice to make for the physical counterpart of the present in Minkowski spacetime is *an appropriately chosen segment of a worldline*. It is obvious that the enterprise of trying to model the present in

Minkowski spacetime is doomed to fail from the start if we don't have a more precise idea of the structure of our experience. In this respect, the notion of a pointlike event is completely *inappropriate* to model the psychological present, since the latter, if anything, has a certain, content-dependent, but *finite (non-pointlike) temporal duration*. This fact is responsible for one of the objections that Savitt raised to the "here-now view of reality" in relativistic spacetimes, involving two observers (Carol and Ted) who are very close to each other in the *same* inertial frame. Combining the stipulation that the present is a spatiotemporally non-extended point with the view that only what is present is real, our two observers cannot recognize their reciprocal existence, (1998, 8) simply because they are located in causally disconnected regions of spacetime. Since if they are close enough, as we are supposing, in real life they *do* share the same present, the point-like event is clearly an inadequate choice for the present of our experience. Can we remedy this situation?

As we are about to see, however, the gain in faithfulness to our experience that could be achieved by considering a segment of a worldline as "the present" is paid in terms of non-invariance. The length of the experienced time along any two segments of two *distinct* worldlines in Minkowski spacetime – representing the different spatiotemporal carrier of Carol and Ted – is worldline-dependent, as the twin paradox notoriously shows.[19] Since this dilemma can serve as an introduction to the only two rigorous results in the literature, to be evaluated later, it is worth delving into it in some more detail.

Without buying into the controversial notion of the "specious present", it is plausible to suppose that if the temporal interval separating two flashes of light presented to a normal subject diminishes more and more, below a certain minimal threshold the signals will be *perceived* as simultaneous. Let us then assume, in accord with various empirical findings (Giulio 1995, 151), that if the two flashes of light, presented as a double pulse stimulation to the rod-free foveal region of the retina, are temporally separated by less than approximately 15 milliseconds (14 to 19 thousands of a second), the two events are judged as being *one*. In this temporal interval, however, a light ray covers approximately 4500 kilometers. Imagine a sphere whose center is in the middle of this room and whose radius is exactly 4500 km. Think first of a flash of light emitted on the surface of the sphere, and then consider another event, coinciding with our turning on the light bulb of the projector right here, in the center of the sphere: the two events would be perceived as simultaneous, despite their distance. This holds, *a fortiori*, for any flash emitted within the sphere reaching our retinas within the temporal threshold given above.

This fact has remarkable consequences. The only reason why we naturally believe that the present extends at a distance is given by the fact that our capacity of discriminating two signals as temporally successive allows light to travel back and forth many times between ourselves and the objects around us (see Stein 1991). In the environment we have evolved, we never had to deal with objects that are hidden behind the visual horizon, and the latter extends far less than 4500 km, and is therefore well within the sphere of what we could call psychological

simultaneity. This is why, in the sense of a "naive physics" implanted in our brains through the evolution, *we have evolved with the "natural" belief that there exists a universe of objects or events that is objectively simultaneously with our perception even if at a distance*. However, from a physical point of view, a cosmic now *need not* exist, and the metric of Minkowski spacetime – by dictating the existence of events that are *not causally connectable* with any event *p*, no matter how small the neighborhood centered in *p* is – clearly *bans* such a temporal structure.

Going back to Savitt's criticism of option (1), it should be now clear why it forces us to switch from Stein's point-like present (the here-now) to *an appropriately long segment of a worldline* (*ct* = 4500 Km), a modification that is capable of explaining why, provided they are "close enough", as it is always the case in our experience, Ted has information about Carol and viceversa within a single act of perception. The light signals have had enough time to travel back and forth between parts of their worldlines on their respective light-cones, a fact that has interesting consequence also for the origin of our concept of *space*. From the above remarks, it follows that the physical counterparts of a set of *subjectively* simultaneous events do not objectively co-exist with each other, *even though in our experience they appear to be simultaneous*. In this sense, space as the order of coexistence is a construction of the perceiving subject in a sense envisaged by Kant, exactly as a picture of the night sky shows objects in its center and on the sides of as if they were simultaneous, while in reality the light that reaches us from the sides took much longer.

In a word, my objection to Stein's assumption that the psychological present is modeled by a point, therefore, is that such an assumption is not true to the facts of our experience that he himself has so clearly and deeply stated. Probably the reason for Stein's avoidance of the identification between our psychological present and a segment of worldline is the loss of invariance. The trouble is, however, that if "we stick to the point", as Stein does, we cannot avoid the difficulties illustrated above about Ted and Carol not sharing their present even if they are very close to each other!

Be that as it may, in order to present my other objections to Stein's theorem – which defines becoming in terms of the relation of past causal connectibility (1991) – let us charitably set this dilemma aside, by stipulating that it can be solved by invoking the approximate nature of models.

5. Becoming and Minkowski spacetime

Once we agree that the present of our experience is to be modeled by a physical point, two of the premises of Stein's theorem are easily justified by the explanatory scheme given above. Clearly, any event that might possibly affect our present experience *a* along the worldline of our body *l* should be regarded *as real with respect to a*. Otherwise, how could it be causally affecting us now? It follows that all events in the causal past of any event *a* should be regarded as having become as of *a*. Furthermore, any event *b* in the causal past of *a* such that

b carries the mark of some previous event *c* in its causal past, makes it the case that also *c* is real with respect to *a*. This gives us transitivity, and, together with our first remark, Stein's first two premises:

1. A becoming relation *B* is a transitive, reflexive relation holding among spacetime events;

2. If any event *a* is a cause of *b*, the former has become (is real) as of the latter, that is, *aBb*.

The other two premises are:

3. the relation *B* is invariant under automorphisms of Minkowski spacetime preserving the time orientation of Minkowski spacetime;

4. for any event *e*, there are events that as of *e* are unreal, or have not become.

While the third premise fulfils the invariance requirement postulated at the beginning of the fourth section,[20] the fourth premise is justified by the fact that if we want to know whether becoming is compatible with the structure of Minkowski spacetime, we need to assume that it is possible, so that at least some events are unreal as of any event of the spacetime. On the basis of these four premises, Stein has proved that for any pair of events *a* and *b*, *a* has become as of *b* just in case *a* is in the causal past of *b*.

Clifton and Hogarth (1995) have later extended Stein's result to the relation of past *chronological* connectibility (becoming along a worldline), in such a way that the latter, together with Stein's past causal connectibility, have been shown to be the only becoming relations that are definable in terms of Minkowski spacetime. This result in particular implies that if a single event, spacelike related with an event *p*, were regarded as being real with respect to *p*, then all events would have to be regarded real as of any other event, a result which gives us an additional argument to reject Weingard's and Putnam's proposals to identify "the now" with a spacelike related region (see 4. above).

Unfortunately, there are three major conceptual problems with Stein's and Clifton's and Hogarth's technical results (SCH from now on). The first involves the EPR paradox and Bell's non-local correlations, which implies, against a consequence of SCH's becoming, that spacelike related events *are* mutually real. The second is the difficulty of interpreting *becoming along worldlines* as a *bona fide physical* becoming, while the third calls into question the origin and nature of the asymmetry of causation, tacitly assumed by Stein and Clifton-Hogarth in their theorems (see the second premise above). As I have discussed the first problem elsewhere (Dorato 1996), here I will conclude my discussion by broaching the second and the third objection in turn.

The fact that the present is reduced to a point shows that in relativity we can't have a global becoming, that is, a becoming in time, but only a local becoming along worldlines, each providing a chronological perspective of the whole spacetime. Here is a defense of this view by one of its few supporters: "What we need not, and I think cannot, conclude is that there is some neutrally describable space-time reality which each of the chronological perspective is a perspective *of*. There is no identity of instants at a distance, and no neutral position from which

the actual state of the world could be viewed *sub specie aeternitatis* – as was possible in the classical picture" (Godfrey-Smith 1978, 242).

This quotation may perhaps reply to some of the difficulties raised by Savitt (1998), concerning the fact that the difference between such pluralistic solipsism and the so-called "block view", in which spacetime is completely laid out, is dubious. Perspectivism just argues that there is no perspective-independent description of the universe, even though all perspectives are equally admissible, just because reality itself is relational and perspectival: "perspective is one of the components of reality. Far from being its deformation, it is rather its principle of organization" (Ortega Y Gasset 1923/1961, p. 91). The block view of the universe argues, on the contrary, that Godfrey Smith's chronological perspectives are purely *mental*, a by-product of the existence of sentient organisms that need to act in a timely way, and whose experienced time agrees locally with the structure of spacetime, which, however, is timeless and, in some sense, the *sum* of all perspectives, as a Leibnitzian God regarded as "the monad of all the monads".

To a certain extent, this conflict reflects in part two broadly construed theories of the aims of our knowledge of the universe. Independently on one's view of the matter, however, it must be admitted that science progressed by trying to "discount" the perspectival effects due to our special position in the universe.[21] Moreover, to the extent that the block-view theorist is correct in arguing that such a "perspectivism", in order to make sense at all, needs *conscious observers*, or at least unconsciously perceiving monads located in every point of spacetime, the strategy of the realist about becoming would be completely useless. Becoming would in fact turn out to be mind-dependent, or at least would require a moderately animistic metaphysics of a Leibnizian sort. The kantian position on the distinction between past and future would be vindicated.

On the other hand, the realist can still reply that the special theory of relativity does not need observers for its formulation. However, even granting that observers are only *possible* occupants of timelike curves, what sense does it make to consider a physical event as the entity with respect to which the *"chronological perspective"* above is referred to? Such a physical event *a* would have to be regarded as bearing in itself all the traces of its causal past, plus the dispositions to transmit the causal influence to the future, but the word perspective, associated to an event described physically, would have nothing but a metaphorical meaning. In any case, associating to the chronological perspective of an event in Minkowski spacetime the sum of the causal influence of its past light cone – an influence whose nature, given a sufficient amount of determinism, is coded in the properties, dispositions, or causal powers of the event itself – still presupposes a *temporally asymmetric relation of causal connectibility*, an assumption that also SCH have *tacitly* made in order to derive their result.

This gives us the third, and more telling objection: on what grounds are we entitled to assume that causation (causal connectibility) is temporally asymmetric? If our aim is merely to show the *compatibility* of becoming and STR, we are free to postpone this worry, as Stein correctly did. But if we are trying to find out whether becoming is a real feature of the universe, such a worry

should become central.

Stein argues that since "the interpretation of the Einstein-Minkowski structure as spatio-temporal depends critically upon the principle that the state at any point *a* is subject to influence by the states at all points in the "causal past" of *a*", it follows that "the states at all such points should be supposed to be definite as of *a*" (Stein 1991, 149). These quotations patently show that Stein is assuming that causation has temporally asymmetric and ontological implications: *if* becoming is real, and if *a* causes *b*, the former event must be definite (real) as of the latter's viewpoint. The converse, however, does not hold, otherwise also events in the future light cone should be regarded as real. But if we are assuming that becoming is mind-independent, from the temporal viewpoint of its cause, each of its possible effects should be regarded as unreal.

Clearly, attributing the arrow of causation such an *ontological status* requires a justification in *physicalistic* terms, in contrast to those theories claiming that the arrow of causation depends only on the existence of conscious agents. If the origin of the arrow of causation were subjective (Healey 1983, Price 1996), *relativistic becoming — depending as it does on a temporally asymmetric causation — would end up being subjective as well*.[22] Consequently, there appears to be an important link between the two main issues of the philosophy of time hinted above that needs to be explored, and that calls into question the relationship between becoming and the arrow of time (earlier and later), the third sense of "ideal/real" required by a kantian approach to time. One of the merits of SCH is actually have brought to the fore such a relationship.

Since I have discussed the issue in another paper[23], here I will simply state the main difficulties. Causation is the fundamental asymmetry of our experience, and clearly depends on the fact that we can act only for the sake of the future. Other asymmetries of our experience, like that of traces, counterfactual dependence and explanation, depend on that of causation: if we backward causation were a common phenomenon, we would have traces of the future and counterfactual dependence of present events on the future rather than on the past, as well as explanation of present events by future causes. Unfortunately for the causal realist, and despite the important role of the asymmetry of asymmetry in our experience, any philosophical analysis that tries to *reduce* such an asymmetry to some physical process, or to an exchange of conserved physical quantities, must rely on *physical laws of conservation* (see Dowe 1992, Heathcote 1989, Salmon 1994). Since the latter are time reversal invariant, Stein's assumption of an asymmetry in the causal relation, at least in physicalistic terms, *is unjustified, unless one can relate it to* de facto *asymmetric phenomena in time*. However, such an association of the direction of causation with entropy growth or positive energy (Faye 1997) would be *extrinsic*: there is nothing in the concept of cause or effect that is in any way linked to physical attributes that make an event into a cause or an effect.

Of course, one could reply that the justification of a direction of causation is in our experience: we cannot affect the past, we can influence the future, so that the latter must be conceptualized as "empty" or open. But if we are trying to decide

whether such an intuition is objective, we cannot rely on a metaphysical elaboration of common sense. It is only physics that can tell us whether causation is *objectively* asymmetric as required by Stein's assumption for becoming: if the only justification for the asymmetry of causation comes from metaphysics, for our purposes we would be moving in a circle.

In view of these difficulties, I think one can safely conclude that *any* form of becoming – even the *tenseless*, relational form advocated by Stein, which has been regarded as a watering down of its stronger, tensed version (Callender 1997) – cannot be reconciled with the special theory of relativity. In any of the choices presented above, the kind of time that one would recover by trying to define becoming in Minkowski spacetime would have so little in common with experienced time that Gödel's claim about the inapplicability of the time of our experience to a mind-independent world seems correct. It is at least ironical to remark that Kant's view of time seems vindicated by that very theory (relativity) that many 20th century philosophers regarded as its official burier.

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[2] Physicists currently engaged in building a quantum theory of gravity are beginning to suggest that "time emerges from the observer/observed relation or just is such a relation" (Rovelli 1997, p. 217).

[3] The question (iii) will not be discussed in full, but only in its relation with (ii).

[4] Correcting Kim's definition to make it relativistically invariant simply entails the addition of a spatial location to the proper time of occurrence, where proper has the technical sense of relativity.

[5] Even though this rendering could be accused by Kantian scholars of being too "psychologistic", here I am only concerned to study the problem of the mind-dependence of the temporal relations and not the conceptual-logical question of the condition of possibility of our knowledge in general.

[6] For Gödel's theory of time, see Yourgrau (1991), Savitt (1994), Wang (1995) and Earman (1995, ch. 6).

[7] A brilliant, contemporary exception is Pauri (2000).

[8] This quotation is taken from manuscript B2, written between 1946 and 1949, and therefore as a preparation to Gödel's 1949a.

[9] "Our observations prove the empirical reality of time, that is, its objective validity with respect to any object that can ever be given to our senses" (Kant 1787, 2 section, ß 6, my trans.). In this context, ideal means that "time in itself, apart from the subject, is nothing" (*ibid*.)

[10] Interestingly, there is some evidence that Gödel regarded causation as a truly, objectively existing relation, giving rise to our experience of succession and change: "The real idea behind time is causation: the time structure of the world is just its causal structure." (Wang 1995, 229).

[11] The passage quoted by Gödel is in the 1787 edition of the Critique of Pure Reason, p. 54.

[12] See Mellor (1981) and Faye (1989), who defend a tenseless ontology and are therefore tenseless theorists.

[13] In Kant's parlance, as Gödel reports it in his unpublished manuscript C1, the three theses presented above correspond to the claims that "time is neither something "existing in itself", nor

"a characteristic or ordering inhering in the objects", but only a characteristic inherent in the relation of the objects to something else"(1990, 247).

[14] Rynasiewicz (1996) offers some good reasons in favor of my ignoring this side of the issue: to the extent that the general theory of relativity fails to distinguish between empty space and matter, the latter theory cannot be invoked to settle the dispute between relationists and substantivalist, which was meaningful only in the 17th century.

[15] Since McTaggart (1908), the series of events going from past, to present to future is known as the A series, while the B series is the series of events ordered by 'earlier and later than'.

[16] Grünbaum (1973), for instance, does not regard the distinction between earlier and later than as being mind-dependent, though he is notoriously an advocate of the mind-dependence of nowness.

[17] A region of spacetime *R* is achronal if and only if any two events belonging to *R* are connected only by spacelike curves.

[18] See also Dorato (1995, ch. 10).

[19] The proper time along a geodesic connecting two point, as is well known, maximizes the length.

[20] The temporal orientation is needed to coherently distinguish the two directions of time.

[21] The Copernican revolution, and the belief that other galaxies are not part of our own Milky Way are two famous examples.

[22] Note that also Clifton and Hogarth (1995), despite their suggestion of a worldline-dependent becoming, need to rely on asymmetric causation. If, as they write, our having lived through certain events is a sufficient condition to regard them as real, an event can be judged to be earlier than another only if the first is remembered while the second is perceived. In other words, one has to have a trace of the first event while one perceives the second as being later than it. And the trace asymmetry presupposes the asymmetry of causation.

[23] See Dorato (2000).

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