

ON BECOMING, COSMIC TIME AND ROTATING UNIVERSES¹

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Abstract

In the literature on the compatibility between the time of our experience and the time of physics, the special theory of relativity has enjoyed central stage. By bringing into the discussion the general theory of relativity, I suggest a new analysis of the misunderstood notion of becoming, developed from hints in Gödel's published and unpublished arguments for the ideality of time. I claim that recent endorsements of such arguments, based on Gödel's own "rotating" solution to Einstein's field equation, fail: once understood in the right way, becoming can be shown to be both mind-independent and compatible with spacetime physics. Being a needed *tertium quid* between views of time traditionally regarded as in conflict, such a new approach to becoming should also help to dissolve a crucial aspect of the century-old debate between the so-called A and B theories of time.

1. Introduction: the shift from STR to GTR and the centrality of becoming

In the literature on the relationship between the time of our experience and the time of physics, the special theory of relativity (STR) has curiously but undoubtedly played a major role. On the assumptions that

- (i) becoming (the "flow of time") is the essential feature of experienced time;
- (ii) *objective* (i.e. *mind-independent*) becoming presupposes an *ontological* difference between *present* and *future* events or state of affairs;
- (iii) the geometrical structure presupposed by STR is a necessary constraint that physical time in general must meet,

a solution to the problem of the definability of becoming in Minkowski spacetime has also been regarded as the main way to solve the question of the compatibility between the time of physics and the time of our experience.²

However, while (i) and (ii) above can be regarded as plausible, (iii) should strike us as suspicious, especially when it is used to claim that *if* Minkowski spacetime cannot make room for any sort of “ontological difference” mentioned in (ii), *then* becoming must be considered to be mind-dependent. An endorsement of the truth of the antecedent of this conditional is usually assumed to have consequences also for the *philosophy* of time one should adopt. For instance, to the extent that a commitment to a mind-independent becoming is regarded as the *essential* tenet of the so-called *A* (or “dynamic”) theories of time, those of their *B* (“static”) rivals that treat past, present and future events as being *ontologically on a par* would be vindicated by the geometrical requirements of Minkowski spacetime.³ On the contrary, if some sort of primitive relation of becoming – appropriately *relativized* to points or worldlines – could be defined in terms of the structure of Minkowski spacetime, the compatibility between becoming and STR would be demonstrated, and no choice between the *A* and the *B* theories of time would be possible only on the basis of physics.

To an unbiased reader, however, such an exclusive worry with STR should appear as puzzling, and in need of a justification. True enough, Minkowski spacetime is the standard, flat spatiotemporal arena for contemporary quantum field theories, but since in the presence of gravitating matter STR does *not* yield an accurate description of physical reality, *it cannot be viewed* – as (iii) obviously presupposes – as a *fundamental physical theory*. Considering that within the general theory of relativity (GTR), STR has only a “*tangential*” validity,⁴ why should we assume that the properties of time that are characteristic of the latter theory also apply to the former? *More generally, why should we assume that time has the same properties across different physical theories?*

Notably, Weyl [1918, p. 220], Eddington [1920, p. 163], Jeans [1936] and Gödel [1949a] were all aware of the fact that the special relativistic limitations *vis à vis* the absence of a *distinguished, global time order* can be regarded as a “local phenomenon”. In fact, the presence and the actual distribution of matter in the large-scale structure of the universe may «largely destroy the equivalence of different observers, and distinguish some of them from the rest, namely those which follow in their motion the mean motion of matter» (Gödel [1949a, p. 559/1990, p. 204]). Unfortunately, in much of the recent literature such an important point seems to have been lost.⁵ One of the main aims of this paper is to redress the balance, by relocating the discussion about becoming and physical time in the more appropriate context of GTR and of cosmological models in general.⁶

Besides having being too absorbed by the infinitesimal, “tangential” features of Riemannian spacetimes, I think it is fair to add that the philosophical literature has never yielded a clear and convincing analysis of the rather obscure notion of becoming, something which has contributed to generate a widespread – but, in my opinion, totally ungrounded – belief in the incompatibility between the time of physics and the time of our experience. Such an obscurity has also affected the formulations of the two major theories that have divided the analytic 20th century philosophy of time. As it should be clear from the above presentation, I take it that the real contention between the “A” and the “B” theories of time does *not* concern the truth conditions of tensed sentences (as Faye [1989] and Mellor [1998] have it), or the relational *versus* the monadic nature of tenses (as Horwich [1987] among others has it). In spite of the obvious importance of these questions, in the following I will take for granted that the crucial, still open rift between the two camps concerns *the nature of change and the mind-independence of becoming*.⁷ Especially within the recent attempts at grounding a quantum theory of gravity, time seems to have lost the independence it had acquired with respect to change in the complex historical path that led from Plato to Newton (see Smith

[2000, p. 928-9]), and today it seems appropriate to regard the notion of time as being inextricably linked to that of change.

Given the importance of a correct understanding of becoming for this project, I plan to begin by proposing a new analysis of such a notion, to be regarded, on the wake of Gödel [1949a], simply as the *successive occurrence* (coming into being) of *tenselessly conceived facts or events* (§2). Armed with such a much needed *tertium quid* between the traditional ontological requirements of the A and the B theories of time, I will then show that *both* Gödel’s argument against the reality of time based on his famous “rotating universes”, *and* its recent reconstructions by Savitt [1994] and Earman [1995], *fail* (§3 and §4). Despite the fact that physics in principle cannot yield a *sufficient* condition for the *tenseless coming into being of events at instants of cosmic time* which becoming consists in, I claim that the cosmological model currently adopted by physicists is completely consistent with it and with the requirements of experiential time, once the latter has been correctly explicated. Finally, by showing that my explication of becoming is faithful to our pre-theoretical intuitions about it and does not run into notorious paradoxes entailed by “the moving now”, I conclude with a simple argument in favor of its objectivity (§5).

2. The nature of becoming and Gödel’s argument for the ideality of time

Gödel’s argument against the reality of time, which appeared in Schilpp’s volume in honor of Einstein (Gödel [1949a]), is based on the discovery of a new solution to Einstein’s field equation, notoriously encompassing the existence of *closed timelike curves* (Gödel [1949b]). The argument is important not only for the conclusion it – unsuccessfully, as we will see – tries to support, but much more for the brilliant analysis of controversial philosophical notions that it provides; from this point of view, it has certainly *not* received the attention it

deserves.⁸ Besides Yourgrau's pioneering work on Gödel's philosophy of time [1991, 1999], which had the great merit of taking into account also Gödel's unpublished material, there are as of now *two* conflicting reconstructions of Gödel's argument for the ideality of time, Savitt's [1994] which endorses it, and Earman's [1995, pp. 194-200], which rejects it, and somehow considers it unworthy of much attention.

Part of the neglect of this argument in comparison to the question of time travel, also raised by Gödel's model, can be explained by the fact that Gödel's argument is incomplete and "gappy" to say the least, as it appears to be centered around the cryptic claim that *since there is no objective lapse of time in his rotating universe, there is no objective lapse of time in our world either*, the main difference between the two models depending only on the way matter is *contingently* distributed and moves. More specifically, in our universe, unlike Gödel's, matter is not everywhere rotating (as Gödel put it, «the compass of inertia does *not* rotate around galactic matter»), *though the physical laws given by Einstein's equations are the same*, as Gödel's model satisfies them. Interestingly, Gödel discovered that the lack of rotation is sufficient to define a global temporal order (see Malament [1995, p. 263]), since the congruence of worldlines of matter corresponding to the major mass points of the universe can be compared to the strands or the fibers of a rope representing spacetime. Absence of twisting, which corresponds to null rotation, is sufficient to slice through the rope with a plane which is orthogonal to every fiber of the rope and *the collection of all such planes is called "cosmic time"*.

To philosophers of space and time, it is indeed reassuring to find out that Gödel's interest in general relativity was *philosophical* in origin, as his mathematical work on time «was spurred by his interest in Kant's philosophy of space and time rather than by his frequent talks with Einstein», which in any case began only in 1942 (Wang [1995], p. 216). In fact, in his "Lecture on rotating universes" [1990, p. 274], Gödel himself tells us that he was

motivated to find his new “rotating solutions” to Einstein’s field equation to rebut an argument due to Jeans [1936], in which it is maintained that the general theory of relativity has reestablished the possibility of an “objective lapse of time”.⁹

In order to thoroughly understand the argument I am about to present below, two terminological points are appropriate. First, it is important to keep in mind that the notion of change that Gödel introduces in the argument is *at variance* with much of the analytic tradition in the philosophy of time, since it requires *an objective coming into existence of facts or events* (this coming into existence he calls: “the lapse of time”). While within such a tradition *change* presupposes just the possession of two incompatible properties exemplified by the same *perduring* entity at two different times, Gödel’s notion of change is tantamount to an objective coming into being, and is to be regarded as an *essential* feature of the time of our experience. In a passage in the manuscript B2, where Gödel summarizes the result of his investigation into the structure of time in STR [1995, p. 236], he writes «what remains of time in (special) relativity theory as an objective reality inherent in the things neither has the structure of a linear ordering nor the character of flowing or allowing of change. Something of this kind, however, *can hardly be called time* (my italics)». In other words, according to Gödel, *time is real only if both a linear ordering and an objective lapse exist independently of observers.*

The second remark is that in the published piece [1949a], he defends also the converse claim that change presupposes an objective lapse of time. These two claims together imply that time is real *if and only if* a change in the existing is real. This equivalence eliminates the charge of circularity in the first three premises of the argument below, and justifies in particular its first premise (0), which in the published paper has no textual support, but is obviously assumed for the sake of the conclusion about the ideality of time.

Whenever possible, each premise of the argument – whose reconstruction owes much to both Earman’s and Savitt’s – is supported by textual quotations from Gödel’s published work [1949a]. Partial conclusions deduced from previous premises are in bold types:

GÖDEL’S ARGUMENT AGAINST THE REALITY OF TIME

Part I

(0) Time is real only if change is real.

(1) Change is real only if there exists an objective lapse of time.

«change becomes possible only through the lapse of time» (1949a, p. 558/1990, p. 202)

(2) Time is real only if there exists an objective lapse of time [from (0) and (1)]

(3) «The existence of an objective lapse of time means or at least is equivalent to the fact, that reality consists of an infinity of layers of “now” which come into existence successively» (1949a, p. 558/1990, p. 202).

(4) Reality consist of an infinity of layers of “now” which come into existence successively only if spacetime admits of a global time function (*cosmic time*).

(5) Time is real only if spacetime admits of a global time function [from (2), (3) (4)]

(6) Gödel’s rotating-model M , *qua* solution to Einstein’s field equations, is a physically *possible* model, and despite the presence of closed timelike curves (circular time) and looming grandfather paradoxes, cannot be ruled out *a priori*.

(7) Since for every x in M , x chronologically precedes itself, M does not possess a global time function.

(8) In the physically possible world M , time is ideal [from (5) (6) (7)]

part II

(9) The main, contingent, non-lawlike difference between M and our universe is given by the (probable) absence of a net rotation of matter, which implies the existence of cosmic time in our world

(10)?

(C) Time in ideal also in our universe

Two obvious questions must be answered in order to see whether Kant's theory of an ideal (transcendental) time is really vindicated by Gödel's rotating universes, as the Austrian logician had it: (i) is the first part of the argument valid? (ii) if it is, how do we bring its conclusion to bear on the status of time in *our* universe, which does not seem to show any rotation of the kind required by Gödel's model (the second part of the argument)? The second question is clearly linked to the problem of filling the premise (10).

3 The first part of Gödel's argument

The unanimous opinion of commentators is in favor of the conclusion of part I of the argument, which proves that in Gödel's universe time is ideal, or mind-dependent. However, some of the premises in my reconstruction, which differs from Savitt's and Earman's, might be regarded as controversial.

For instance, and firstly, it could be objected that (1) – and therefore (2) – are not plausible, as they imply the dubious theory of an *absolute change in what exists*, rather than

an ordinary, *qualitative* change of what already (tenselessly) exists, as in “the party *became* boring” or “the traffic light became red”. *Absolute change* in this sense is what Gödel called “a change *in the existing*”, already distinguished from *qualitative change* by C. D. Broad long ago: «To “become present” is, in fact, just to “become”, in an absolute sense; i.e., to “come to pass” in the Biblical phraseology, or, most simply, to “happen”. Sentences like “This water became hot” or “This noise became louder” record facts of *qualitative change*. Sentences like “This event became present” record facts of “absolute becoming”» [Broad 1938, p. 280]. To counter this first objection to Gödel, it is then important to keep in mind that “change” as used in premise (0) refers to *absolute* change (absolute becoming) in Broad’s sense, to be carefully distinguished from a *qualitative* change of events losing the (pseudo-attribute of) “being future” and becoming present.

Secondly, it might be objected that (2) implies the dubious “moving now” conception of time (see Earman [1995] and Savitt [1994, p. 468]), since it is always possible to ask “how fast does the absolute change in what exists occur?” However, as anticipated earlier, I argue that the claim that instantaneously conceived events (or facts) “come into existence” at a certain time (the “objective lapse of time” in the above argument) is simply equivalent to the claim that *they mind-independently occur at that time*. Consequently, Gödel’s locution “events come into existence successively” should really be read simply as “events (*mind-independently*) take place one after the other at their time of occurrence”.

In a word, as I interpret it, the objective lapse of time or the “*change the existing*” referred to by Gödel amounts to the rather non-metaphysical, almost self-evident claim that if “event *E* occurs (or, equivalently, tenselessly exists) at time *t*”, at a later or earlier time *t*’, *other events occur (exist)*¹⁰. This means that, at time *t*’, the set of existing events includes events *other than* those existing at *t*. With this stipulation, our language regimented in a logical way

would have a domain of quantification for each time, containing only those entities that then exist.

To come now to the charge that an objective coming into being, or the “flow (lapse) of time” as it is interpreted here, implies the fallacious “moving now”, note that one could simply point out that the absolute change in what exists is no ordinary change, and as such, *it does not conceptually depend* on other notions as the latter does.¹¹ The reason why it is *simply meaningless* to ask “how fast does such a change in the existing occur?” is given by the fact that the notions that are synonymous of becoming or “coming into existence”, namely “occurring” or “happening”, *are not further analyzable*; in any case, they don’t presupposes a perduring entity and a pair of incompatible properties possessed by the same entity at different times as the qualitative notion of change does. It is only in the ordinary sense of change – the qualitative change of, say, a *piece of iron* becoming *rusted* – that one can talk about *the rate* of change, since any change *in* time can be slow or fast (a slow aging or rusting, a fast aging or rusting). Of a change *of* time, one cannot even say that *it occurs* – though it can be regarded it as a feature of the universe quite independent of our minds – since, *strictly speaking*, it is only events that can occur at times, and their succeeding one another at different times is *not* an event, if the latter is defined as an instantaneous entity as is customary in relativity.

A third objection a tenseless theorist of time might have against (1) above is that it ignores the tenseless aspect of time. According to the tenseless theorist, events are mind-independently *before* one another, even though they *are given in block*, because they don’t become, or don’t come into being or cease to exist (*the block universe*). In a word, for certain B theorists like Mellor and Faye, tenseless temporal relations – and therefore, in a sense, time – are real even if the lapse of time usually advocated by the A camp (i.e., the coming into existence of events) is mind-dependent, so that (2) is false.

As a reply to this third criticism, note that even if we changed (2) above by requiring that (2)' Time is real only if the distinction between before and after is mind-independent (objective), a tenseless theorist would still have a harsh destiny in *M*. Given the existence of closed timelike curves for any point of Gödel's spacetime, an observer whose spatiotemporal carrier coincided with a segment of such curves would have no justification for claiming that *beforeness or afterness* is mind-independent. Events of type *E* that she would experience as being before events *F*, on a closed timelike curve would also be such that *F* is before *E*, so that, in such a Gödelian world, *temporal betweenness* would seem the only objective relation «inhering in events». Consequently, as Kant had it, in Gödel's universe it would be plausible to assume that time as we experience it emerges from the relation of our faculty of perception with the «things in themselves», which established the conclusion of the first part of the argument.

In order to give further arguments in favor of premise (2), it is of paramount importance to keep in mind that when Gödel refers to "time", he always means "the time of our experience", or «what everybody understood by time before relativity theory existed» (1990, manuscript C1, p. 247). In particular, this implies that, in any case, premise (1) – and (2) – *do not purport to say something about physical time or the metaphysics of time in general, but only about mental, experienced time*. Considering that the overarching purpose of Gödel's paper is to reevaluate Kant's theory of time and show that it is not only compatible with relativity but even vindicated by it – as is also clear from the opening paragraphs of the two manuscripts preceding [1949a] – premise (1) needs no justification from the moving-now conception of time, as Earman speculates [1995, p.199]. Premise (1) is assumed only to prove that if spacetime does not make room for a necessary condition for *objective* (mind-independent) coming into being, namely cosmic time, Kant's thesis about the ideality of time

would be correct, *against the prevailing opinion of 20th century philosophers of space and time*.¹²

A fourth controversial point of the first part of Gödel's argument might concern the condition of *globality*: one could object that in the spacetime of general relativity, such a condition may not be necessary to the existence of a lapse of time, and therefore question premise (4) above. One could conceive a local, mind-independent coming into being along single worldlines also in a Gödelian universe, not matched by analogous phenomena at a cosmic scale. Likewise, the absence of an invariant, global time order in STR could be compensated by a worldline-dependent becoming, as is proposed by Clifton and Hogarth [1995].

In the same fashion, for example, Boltzmann thought that the universe could be in a global state of thermal equilibrium, while some regions, large as a cluster of galaxies, could be characterized by gigantic, rare fluctuations, due to which, for some billions of years, observers would reckon an increase of entropy, and therefore some sort of objectively irreversible phenomena (Boltzmann [1896-98/1964]). Would we deny that entropy grows in those regions simply because at a larger scale, both spatially and temporally, the universe is in equilibrium? I doubt it. But then, why can't we say that some sort of local becoming takes place in a mind-independent way?

Gödel would probably object that by admitting a local coming into being, where "local" here has the same sense it had in Boltzmann's "pockets of increasing entropy lasting for eons", we would make a change in the existing – the lapse of time – *relative* to particular worldlines, i.e., to *some possible observers* living in a galaxy. And then, he would add: «The concept of existence (...) cannot be relativized without destroying its meaning completely» [1949a 559/1990, 223, fn. 5].

However, note that if we cannot relativize the concept of existence, an examination of the impact of the special and the general theory of relativity on our ordinary notion of time would be meaningless since, *independently of relativistic considerations*, such a relativization is implicit in the very idea of a lapse of time even according to Gödel. In our experience, as he wrote, *we often assert of the same event that «it exists and it does not exist, at two different instants of time»*. Furthermore, without such a relativization, we would be subject to some form of McTaggart's paradox about events being present (existent) and non-present (non-existent) *at the same time*. These remarks are of paramount importance, since not only do they entail that a relativization of tenses is necessary, but also that it does not lead us to a view of becoming that is too deflated to be worth having (see Callender [1997, p.118]). Elsewhere (Dorato [1995]), I have argued that there cannot be a *future* event in an absolute sense, since an event can count as future only relatively to some present event or other, and human existence appears always temporally located and perspectival, that is, experienced at each instant of time from the perspective offered by that instant. Here, let it suffice to say that, beyond the possibility it offers of re-establishing a compatibility with physical time, the main reason why one wants to defend such a perspectival, relational understanding of existence in time is that without it we could not make room and explain our capacity to literally *bring about a future event* by acting in the present: "making things happen" presupposes that events that are yet to occur and are brought about by our efforts do not (tenselessly) exist relatively to the moment of action. If they did, our action and our experience of passage would be both illusory, and utterly unexplainable.

Granting the possibility of relativizing the concept of existence in this sense, a much more plausible defense of the condition of globality is that, by rejecting it at least in the context of Gödel's spacetime, we would make the lapse of time non-intersubjectively valid: «in whatever way one may assume time to be lapsing there will always exist possible observers

to whose experienced lapse of time no objective lapse corresponds (in particular possible observers whose whole existence objectively would be simultaneous)» (Gödel 1949a 561/1990, 205-6). Gödel here refers to hypothetical observers O_1 , whose worldlines lie *beyond* a certain critical point P of his spacetime model, characterized by the fact that the light cones at P are *tangent* to the hyperplane of simultaneity determined by those observers (call them O) that are located in the conventionally chosen axis of rotation of Gödel's universe. Since, beyond P , O_1 's closed *worldlines belong to a hypersurface of simultaneity* determined by O , O_1 's *whole* existence along the circular time-like curve would be simultaneous *with a particular instant* in O 's existence.¹³ In view of this peculiarity of Gödel's spacetime, I take that in the context of the argument under discussion it is plausible to grant Gödel's implicit condition of globality, in such a way that an objective lapse of time must be a lapse for all *possible* observers (worldlines) of the spacetime. In a word, making a reasonable "equation" between a possible observer and a worldline, within Gödel's cosmological model the *objectivity of becoming must imply its intersubjective validity*.

We can therefore conclude that if we lived in Gödel's universe, we should be Kantian about time, since both the difference between earlier and later and that between present and future would be mind-dependent.

4 The second part of Gödel's argument: why the epistemic defense fails

How does the valid conclusion of the first argument impinge on the way we should understand time in *our* universe, where the distribution of matter is different? There are two possible interpretations of Gödel's argument, an *epistemic* one and a *metaphysical-modal* one, pointing to the necessary grounding of cosmic time in the laws of nature. Here I will limit myself to the former interpretation, which is essentially due to Yourgrau [1991] and

Savitt [1994]. Not only is this choice motivated by the fact that it has generated more discussion than the latter, but also by the remark that the metaphysical interpretation has unanimously been regarded as being extremely difficult to justify.

Suppose, with Savitt [1994], that in a physically possible Gödelian model, there are inhabitants like ourselves measuring a *local time* t_L in the local «compass of inertia», in such a way that whenever x temporally precedes y for any two events in the galaxy where the Gödelians live, $t_L(x) < t_L(y)$. Then it could be argued that the direct experience of time of the Gödelians is exactly like ours. On the basis of this remark, Savitt has thus reconstructed Gödel's reasoning:

(10) it is possible to have direct experience of time just like ours in a universe in which (as in M) there is no objective lapse of time; [recall (8)]

(11) such an experience provides the *only* reason to suppose that there is an objective lapse of time in our universe;

(12) «our direct experience of time provides no reason to suppose that there is an objective lapse of time in our universe» [from 10 and 11]

(13) «Since there is no objective lapse of time in M , there is *no reason* to suppose that there is an objective lapse of time in our universe» (Savitt [1994, p. 468]).

[from 8 and 12]

This reconstruction has the undeniable merit of being faithful to the text, as it is probably spells out what Gödel had in mind when he wrote:«if the experience of time can exist without an objective lapse of time, no reason can be given why an objective lapse of time should be assumed at all.» (Gödel [1949a, p. 561/1990, pp. 205-206]).

Such an epistemic interpretation of Gödel's argument had already been anticipated, somewhat more concisely but less perspicuously, by Palle Yourgrau: «Since the actual world is lawlike compossible with the Gödel universe, it follows that our direct experience of time is *compatible* with its ideality (assuming with Gödel, its ideality in the Gödel universe). But if even *direct experience* is inadequate to establish the existence of intuitive time – that is, not merely (relativistic) causal or cosmic time, but genuine, successive time that lapses or passes – *then nothing further* will suffice» (Yourgrau [1991, p. 53]). In a word, Yourgrau-Savitt's *epistemic* argument weakens Gödel's attempted conclusion, as it amounts to *shifting the burden* of proof to the defenders of the reality of the time of our experience.

The latest attempt at an evaluation of the gist of this argument is Earman's, who, in the appendix to the chapter 6 of his [1995], examines Yourgrau's version as is reported above and rejects it – he does not discuss Savitt [1994], as the paper was probably in press. Earman tells us that «*apart from our experience, we have all sorts of evidence that lend strong support to the inference that we do not inhabit a Gödel type universe, but rather a universe that fulfills all of the geometrical conditions necessary for an objective lapse of time.*» [1995, p.199].

Unfortunately, it seems to me that Earman has misconstrued Gödel's argument and Yourgrau's main point. The crux of Gödel's argument is *not* that our scientifically tutored experience, together with inferences to theoretical structures, *does not suffice* to establish that we live in a universe endowed with *cosmic time*, as Earman seems to have it. Rather, Gödel's point, as correctly reconstructed by Yourgrau and Savitt, is that after the discovery of the rotating solutions to Einstein's field equation, *our experience alone* (without the help of independent arguments) *is not sufficient for objective becoming, i.e., for establishing the existence of a mind-independent lapse of time.* Since in the quotation above Earman himself explicitly recognizes that cosmic time would be a merely *necessary* condition for an objective

lapse of time, he cannot be interpreted as denying premise (11) above, namely that we have independent evidence for becoming *because* we have scientific evidence (as we do) for the existence of cosmic time. Consequently, if a realist about time and becoming wants to attack Gödel's argument, she must pick up Savitt's challenge, and discuss his two premises, namely (10) and (11).

Starting with the former, could the experience of the Gödelians be identical to ours? If we grant this point, obviously we deny that there exists a *necessary* link between what we experience and the structure of objective, cosmic time also in the *actual* world, and it may seem that Savitt's premise, to a certain extent, simply *begs the question*. The point, however, is not that such a premise is question begging, but rather that *since* the logical and physical possibility of time travel is needed by Savitt for Gödel's universe not to be ruled out *a priori*, it is certainly available to an antikantian (a realist about time) to claim that *it is at least physically possible* that the experience of time of the "Gödelians" be very much *unlike* ours.¹⁴

Savitt might perhaps defend his premise by invoking well-known technological difficulties entailed by time travel. Observers living in Gödel spacetime would presumably share our technological problems concerning the amount of acceleration and fuel needed to voyage into the past (Malament [1985]), and would not *actually* be traveling into the past, though it would be *physically possible* for them to do so. Moreover, we have to keep in mind that Savitt's premise (10) merely relies on the *physical possibility of their experiencing time exactly as we do, and this point is not touched by the mere possibility of time travel*.

If time travel in this context is a red herring, there is another difficulty that stands in the way of our accepting (10): to say that it is physically possible for local observers living in Gödel's spacetime to experience time as we do implies that it is physically possible for such observers *to fail to see any trace of the future*. This is highly doubtful, however, since it is certainly physically possible for them *not* to be screened off from causes that are *later* than

their effects, exactly because they live in a universe in each point of which a closed timelike curve can always be found! One can even argue that in Gödel spacetime *there must be traces of the future*, since even if the Gödelians' psychological arrow is directed along one direction of time, and that direction is picked out as *the* direction of time, some later events along that direction will have to be regarded as indirectly causing events in the observers' present. So, especially if such observers live along timelike "loops" whose diameter is not very large,¹⁵ we can conclude that their experience of time would be relevantly different from *ours*, and Savitt's basic premise would have to be abandoned. At this point, he might retort that for observers living on very large causal loops, causes that are later than their effects would be very improbable, and the technological difficulties of traveling into the past might just make their experience indistinguishable from ours.

Leaving to the reader the difficult task of judging who is going to score on this uncertain point, let me strengthen my objection to Savitt's argument by considering that also premise (11) is debatable: is our "direct experience of time" the only argument to believe in the objectivity of the lapse of time? Clearly, an evaluation of this claim depends on how to understand "our experience of time", in particular the ambiguous and vague word "experience". If Savitt means to claim that no argument in defense of an objective coming into existence is ever likely to come from physics ("experience" meant in a very wide sense, encompassing scientific knowledge), I think we must agree, because cosmic time cannot be regarded as *sufficient* for objective becoming. Furthermore, it is certainly not among physics' aims to yield a distinction between physical systems or entities that are *actual* at a certain time and systems that are merely *possible*, and precisely this distinction is needed for becoming. Consequently, in his argument "experience" must mean "scientifically untutored experience". However, even in this restricted sense, "experience" can have two interpretations, a *broad* and a *narrow* one.

In a broad sense, one could refer to “experience” as it is coded in ordinary language, particularly in those concepts – possibly *a priori* for the individual but *a posteriori* for the species – that have been acquired during our evolutionary history and that are tested, say, in experiments within the so-called *naive physics*. These “concepts” (time included) must possess some sort of *adaptive value*, in the sense that they must enable us to cope with the environment in a successful way, despite their approximation and possible lack of precision for purposes of the scientific description of the world. If we interpret “experience” in such a *broad evolutionary, not purely psychological, sense*, we may even grant Savitt’s premise (11), by remarking at the same time that the adaptive value of our naive concepts of “object” and “property” may justify some sort of general, defeasible “folk realism”, telling us that such objects and their properties are *prima facie* real. Rather than calling into question and “eliminate” what Sellars [1962] used to call “the manifest image” (the world of our experience), we may temporarily adopt its ontology, *until conflicts with the “scientific image” force us to abandon it*. On this hypothesis, however, why doubt that there is something mind-independent that our experience of time is about, *if in our model of the universe no scientific fact is in direct conflict with it?* In our universe, unlike Gödel’s, one *can* be a folk realist about becoming *since a necessary condition for it – cosmic time – is indeed satisfied*. In this line of argument, rather than arguing directly for the reliability of our experience of time, one could begin by defending, indirectly, some sort of folk realism, which would then support in a non-ad-hoc way also our “natural belief” in objective becoming, once conflicts with known physical theories are shown to be absent.

If, on the other hand, “experience” is given a *narrower, purely psychological* reading, isn’t it quite hazardous to deny, at the present moment, that *any future philosophical* arguments constructed to prove the reality of the lapse of time must fail? For instance, Tooley [1997] has recently given an important argument in favor of the unreality of the future based on

causation, not on our “psychological” experience. How can we exclude that forthcoming and more sophisticated arguments will succeed without calling into question our mental set-ups?

In sum, I don’t mean to suggest that Savitt’s reconstruction of Gödel’s argument is not interesting and persuasive, but only that it is *not conclusive* to establish the mind-dependence of becoming or the ideality of time in the sense of Kant. In the remainder of the paper, I will pick up Savitt’s challenge (recall the shift of the burden of proof) by defending the mind-independence of a somewhat “deflated”, minimalist and *tenseless* notion of becoming, which concerns our experience only in the broader, non-psychological sense mentioned above. As we are about to see, such a notion is nevertheless a satisfactory explication of our intuitive notion of time

5. Becoming as real occurrence of events and facts

My suggestion is to explicate, or rather simply *equate* becoming with the notion of “taking place” or “occurring”, which is also the natural way to understand *change* in Broad’s absolute, non-qualitative sense referred to above:

*Def: Becoming is real if and only if events successively and mind-independently take place at their own proper time of occurrence.*¹⁶

Given that it is non-controversial to grant that for an event to *occur at a time* just means for it to *exist at that time*, the task that still remains is to show that the proposed, minimalistic equivalence between ‘coming into existence at time *t*’ (Gödel’s change) and ‘occurring (existing) at that time’ captures the essential features of our pre-theoretical intuitions about becoming and the passage of time.

The solution we are after is simple if we identify the lapse of time with the view, dearest to our intuition, that the “present coincides with the existing”. By relativizing this claim to a

time t , we get that at t only events simultaneous with (present at) t exist, where “existence” is here understood in a relational, tenseless sense, given by “existence at a date/time”. Capturing this intuition in our explication of becoming is therefore indispensable to make the latter adequate, and it seems to me that Gödel has understood this essential point better than any other philosopher before or after him. Consider the following, precious but strangely neglected quotation: «For that time elapses and change exists means [...] that at any moment of time only a certain portion of the facts composing the world exists objectively (and different portions at different moments)» [Gödel 1995, p. 235]. Provided that the notion of occurring at a certain proper time is mind-independent – why deny that “things occur” and “events happen” without our taking notice of them? – the thesis *that only the present exists* (even formulated in the relativized way seen above) *is sufficient to claim that events and facts come into existence (and cease to exist) mind-independently*.

In fact, *how can two temporally separated events coexist in a tenseless sense if, at any instant of (cosmic) time t , only events occurring at t exist (at that time)?* For any two temporally separated, instantaneous events e and f , the earlier of the two must cease to exist when the other comes into being, provided that “event e comes into being (into existence) at t ” (tenseless becoming) simply means “ e occurs or happens at t ” or “ e is present at (simultaneous with) t ”. The first, essential question we must face, then, is whether, and in what sense, events can be said to *coexist tenselessly* in the same possible world (spacetime), or alternatively, which arguments we have to defend the view that only what occurs at t exists at that time. The other problem is to show that such a relational, tenseless view of becoming is a *faithful* explication of our experience of time and passage. Let us examine these two issues in turn.

The argument to defend the view that at time t only what then occurs exists as of that time may run as follows. For simplicity, imagine a universe in which time has a discrete ordering,

composed only of instants 1 and 2, with two causally connectible, instantaneous events, E_1 and E_2 , occurring at those temporally separated instants. At t_1 , E_2 trivially doesn't exist (both in a tenseless and in a tensed sense of 'existence'), simply because, by definition, E_2 *occurs at the different time t_2* !¹⁷ In fact, if 'occurring at t ' and 'existing at t ' must be regarded as perfectly interchangeable, *tenseless* expressions, it follows that at time t_1 , E_2 does not exist, otherwise E_2 would exist *at all times* (that is, in our simplified model, it would exist also at t_1), which is absurd. Therefore, since at time t_1 E_1 exists (occurs) and E_2 doesn't (in the perfectly acceptable tenseless sense seen above), one can safely assume that E_2 *comes into being at t_2* , by simply happening or taking place at that time. Conversely, since E_1 exists (occurs) only at t_1 , at t_2 it *ceases to exist*, since at that time E_2 is the only existing event.

By defending such a *tenseless and relational* view of becoming, one can readily join Williams [1951] in arguing that the *flow* of time interpreted in a *literal* sense is inconsistent, because of notorious difficulties with questions like "how fast does the present flow"? Of course, renouncing this view is certainly not a sacrifice, because the explication of becoming proposed here – by broaching this problem we come to the second issue anticipated above – does indeed save two essential tenets of the commonsensical view of time:

- (i) At any instant of time, only what is present at that time exists, since both the past and the future at that time don't exist (both in the tensed sense of existence, given by "existing now" and in a perfectly acceptable tenseless sense, given by 'existence at a date/time')¹⁸;
- (ii) an absolute change in what exists can be regarded as objective, since it coincides with the successive coming into being (occurring) of events either (a) at different instants of a global, cosmic time, if the latter is indeed available, or (b) at instants of a local, proper time along a particular worldline.

I argue that such a successive coming into being of events at different moments of time is *the mind-independent, objective core* lying behind the *subjective sense of literal passage of one time over another*, which, admittedly, is engendered by our memory of events that don't exist any more and our anticipations of events that are yet to happen, fused together in a unique but continuously changing present experience. The changing of such an experience can be explained only with the successive coming into being of events and states of affair at their time of occurrence.

It is in this sense that I think that such a minimalist view of becoming, that in the literature has never been clearly formulated, can be regarded as a *tertium quid* between, and therefore as a *dissolution of*, some of the main contentions between the two camps (the “A” and the “B”) in which the analytic philosophy of time of the 20th century has been divided: despite the fact that tensed sentences have tenseless truth conditions – as urged by Mellor [1981] and Faye [1989] – becoming must be regarded, *contrary to the typical B-theorists' view*, as a *mind-independent* feature of the universe.¹⁹ At any instant of a cosmic or local time, tenselessly conceived events and facts do come into being as objectively as it gets, for the simple reasons that at any instant of time, only events occurring at that instant exist (in the two senses seen above), and such events do not occur all at once, but in succession. Furthermore, once we realize that it does not make sense to ask how fast events do come into being, because coming into being at *t* just means occurring at that time and not existing before, the ghost of the infinite regress, imported by misleading metaphors of motion through space of a reified now, vanishes.

Incidentally, we should note that the view that mind-independent occurring (on the part of events) is sufficient for becoming is not completely new, since it has been *implicitly* defended by authors that are usually identified as arch-enemies of becoming, like Eddington: «events do not happen, they are just there and we come across them» [1920, p. 51), and Weyl «the

objective world simply is, it does not happen» [1949, p. 116]. I claim that these oft-quoted passages, whose true meaning has escaped us, are the only coherent formulations of a becomingless world, i.e., a world in which events literally *don't occur*, but simply *are*.

It should be obvious why both Weyl and Eddington defended this view with respect to STR. Given that in this theory the temporal order is only *partial*, events that are usually defined, as in Kim's theory [1976], by a *triple* constituted by a substance, a property and a (coordinate) *time*, would have to be regarded as having an identity which depends on an arbitrary choice of an inertial frame. In this case, it may appear more plausible to assume, as Eddington and Weyl did, that events don't occur at all, but simply are, or tenselessly coexist in the block view of the universe. If my reading of those oft-quoted passages is correct, these two philosophers had already realized what I am urging here, namely that for the reality of change and of temporal becoming, the reality of "occurrence" *suffices*. This, in its turn, implies that as soon as we grant that in a general relativistic spacetime endowed with a *global* time order events can objectively and mind-independently occur in succession, we thereby introduce a change in what is real at different instants of time for the reasons given above, and therefore a tenseless form of becoming at a cosmic time *t*. It is certainly more difficult to defend a local, worldline-dependent becoming in the Minkowskian setting, since the present there does not extend in space but must be identified with a point (the "here-now"). However, this is the topic for a different paper.

6 Conclusion

Even if the argument above in favor of becoming were not judged to be conclusive, what matter most for my purpose is that the adoption of a relativized and tenseless notion of becoming yields a coherent alternative to its mind-dependence and to the block view. We can

adopt *the view from no-when* of the block universe, a God's eye point of view, which describes entities that are temporally extended *sub specie aeternitatis*, or we can resort to a relationist, perspectival description of reality, which refers existence to a particular "point of view" or instant of time. If both are compatible with known physical theories, the choice between them can be only be a matter of overall coherence with what else we know about the universe.

The reasons to prefer the latter view are not only pragmatic, i.e., given by the fact that we *are* temporally located beings. The former view, by regarding the difference between *present* and *future* events as identical to the difference between *here* and *there*, makes our experience of time utterly unexplainable, and in principle not describable in physicalistic or even naturalistic terms. In fact, how can I act to produce or bring about a future event *e* if *e* coexists (tenselessly) with the time of my action in the same sense in which a past event exists? Within the perspectival, relationist option, causation *can* be regarded as an ontologically loaded notion: from the perspective of a region *R*, from my present action is located, events occurring in the later region *R'* don't exist (tenselessly or tensedly), and an event in *R* (my action) literally *brings about* those in *R'* *by causing them*.

If what I am trying to argue is correct, it follows that a somewhat deflated version of objective becoming must be reintroduced, one that is equivalent to the notion that events mind-independently occur at a certain proper time and place. If the proper time of a single, fundamental particle (observer) can be extended to a cosmic time as in standard Robertson-Walker cosmologies, becoming can be regarded as being independent of the varying lapses of time associated to different timelike curves, and, as such, it passes the test of intersubjective validity. *If* there is a perfectly legitimate sense in which physical events belonging to any relativistic spacetime (also Minkowski's) exist only at their proper time and place of occurrence – no interpretation of relativity forces us to abandon this trivially simple remark –

it should be clear why this view of becoming entails some sort of *rapprochement* between the so-called static view of time and the dynamic view: the only existing facts are tenseless (facts at times) but their becoming or coming into being at instants of cosmic or local time is a *real, though physically unexplainable feature of the universe*.

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² See Rietdijk [1966], Putnam [1967], Stein [1968, 1991], Weingard [1972], Godfrey-Smith [1979], Maxwell [1985], Dieks [1988], Clifton and Hogarth [1995], Dorato [1996, 2000], Rakic [1997], Tooley [1997], and Savitt [2000] among others.

³ For a recent survey on the debate between the A and the B theories of time – whose formulation dates back to McTaggart [1908] – see Le Poidevin [1998]. For reasons that will become clear in the following, rather than referring to the debate by using the misleading terms “tensed” and “tenseless” theories of time, I prefer the more neutral “A” and “B” theories of time.

⁴ The pun of “tangential” refers to the validity of STR in planes that are tangent to each point of a Riemannian manifold of GTR. The pun is in Savitt [2000].

⁵ Saunders [1996] offers a brief discussion of cosmic time in the context of Gödel’s argument, and defends a relational view of tenses with which this paper is in complete agreement, though he would probably disagree with the view of becoming presented here. Yourgrau’s [1991], Savitt’s [1994] and Earman’s [1995] contributions will be discussed below.

⁶ Of course, GTR might end up being a phenomenological, derived theory as well. However, until a reasonably agreed upon quantum theory of gravity is available, we can assume that GTR *is* a fundamental physical theory.

⁷ Here I follow Tooley [1997], who has convincingly argued that granting (as I do) (1) that the truth-conditions of tensed sentences are given by tenseless sentences and (2) that tenses are relations, does not yet solve the problem of becoming and of the ontological status of future events, which is what I am after here.

⁸ Though Stein [1970] had already stressed its philosophical significance.

⁹ The English word used by Gödel, “lapse” comes from the Latin *labi*, which means to flow. So lapse of time is equivalent to flow of time, in the way to be clarified below.

¹⁰ “Exist” here is meant in a tenseless sense, given by “existing at a time”.

¹¹ As anticipated in note 1, this is the line also taken by Savitt in his contribution to this volume. As a matter of fact, we arrived independently to the same conclusion about the importance of carefully distinguishing *absolute* change from ordinary qualitative change in Broad’s sense.

¹² “Prevailing”, however, does not mean all: witness the contemporary theoretical physicist Rovelli, and the way he concludes his overview of the problem of time in quantum gravity: «If *time* is the order of the changes in the states of the systems, and if the state of a system is a relational notion, one that has meaning only if referred to an observer, can there be time outside the observer/observed relation? Is perhaps time precisely what emerges from this observer/observed relation? Is time precisely such a relation?». Rovelli [1997, p.217].

¹³ For a vivid representation of this situation, I refer the reader to the picture in Malament [1985]. See also Savitt [1994, note 10].

¹⁴ Of course, Savitt acknowledges that after a bit of scientific development, the gödelians might discover that there is no cosmic time in their universe, i.e., no necessary structure for the existence of an *objective* lapse of time [1994, p. 467].

¹⁵ This remark was raised by Joos Uffink during the discussion of the paper.

¹⁶ Interestingly, the etymology of ‘event’ betrays an original, revealing image of motion through space, as the word comes from the Latin verb *advenire*, literally “to arrive”, “to come from”, which is then extended metaphorically to temporal matters to mean “to occur”, “to happen”, where such happenings *are changes*.

¹⁷ For the purpose of rebutting charges of fatalism allegedly entailed by the tenseless view of time, this point has been correctly noted already by Oaklander [1994, 1998]. However, I think that he has not drawn its philosophical consequences for the view that he himself defends about becoming (he is against it).

¹⁸ The fact, urged by Savitt, that other senses of tenseless existence are on the ground (“existing at all times” is one) is irrelevant in our context.

¹⁹ For a number of B-theorists defending the mind-dependence of the difference between past, present and future, see Russell [1915], Grünbaum [1963], Faye [1989], and Mellor [1998]. Not all B theorist defend the mind-dependence of becoming: J. Butterfield (private communication) is an exception.