

FOUR DEGREES OF TEMPORAL BECOMING

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ABSTRACT

The block universe theory of time is commonly said to be incompatible with temporal becoming. This confuses Maudlin who upholds both eternalism and passage. The aim of this paper is to answer Maudlin's plea for clarification by distinguishing four degrees of temporal becoming. After discussing their respective compatibility with the block universe, I show that Maudlin asks much less from temporal becoming than most philosophers of time. Consequently, his form of becoming is compatible with the block, whereas the stronger forms of becoming are not.

Keywords: temporal becoming · block universe · passage of time · absolute becoming · relational becoming · presentist becoming · dynamic becoming

*The Moving Finger writes; and, having writ,
 Moves on: nor all thy Piety nor Wit
 Shall lure it back to cancel half a Line,
 Nor all thy Tears wash out a Word of it.*
 — *The Rubáiyát, Omar Khayyám*¹

AN INVITATION FOR CLARIFICATION. In a book symposium on Bradford Skow’s *Objective Becoming* (2015), Tim Maudlin (2018) distinguishes the philosophers of time (such as Skow) from the philosophers of physics (such as Maudlin himself). Both groups have deep interests in the nature of time, but their lingo only partly overlaps. Philosophers of time write about “tensed” and “tenseless” theories of time, and about “A-theories” and “B-theories”, whereas philosophers of physics do not.

“I am not a philosopher of time”, Maudlin (2018, 1807) confesses right away. “And for the life of me, I still don’t know whether the views I hold [...] constitute a “tensed” or “tenseless” view; an “A-theory” or a “B-theory” (p. 1808).² Another terminological source of confusion is Skow’s use of the terms “anemic” and “robust” when discussing change and passage.

Even more troublesome to Maudlin is the alleged incompatibility between the block universe (BU) theory of time and robust passage.³ Indeed, most philosophers of time seem to agree that if the BU theory holds true, then time does not pass. Maudlin, on the other hand, believes he is committed to both the BU theory of time *and* robust passage, and does not see the problem with that.⁴

The aim of Maudlin’s review, therefore, is twofold: first, to critically comment on Skow’s *Objective Becoming* (and in particular, on his use of the terms “anemic” and “robust”); secondly, and perhaps more importantly, to ask Skow and the other philosophers of time for clarification. “I just want to know where [my views] fit in the usual set of distinctions”, writes Maudlin (p. 1808) — hoping that such an elucidation will help to reunite both camps. “’Tis a consumation devoutly to be wished”, he concludes (p. 1814).

FOUR DEGREES OF TEMPORAL BECOMING. The goal of the present paper is to answer — at least in part — Maudlin’s plea for clarification by distinguishing *four degrees of temporal becoming*: (1) absolute becoming, (2) relational becoming, (3) presentist becoming and (4) dynamic becoming.⁵ The higher the degree, the stronger the form of becoming and, I argue, the less compatible with the BU ontology.

I show that Maudlin’s view on the passage of time corresponds to a form of relational becoming, whereas Skow’s view on robust passage seems to correspond to a form of dynamic becoming. Maudlin thus subscribes to a strongly deflated form of becoming as compared to Skow’s robust becoming.

¹ Quoted from FitzGerald (2009, 41).

² In his reply to Maudlin, Skow (2018a) briefly addresses this issue, but Skow seems to be as confused about Maudlin’s views of time as Maudlin is about Skow’s.

³ Maudlin (2018, 1809) thus writes: “when Skow frames the debate as between ‘the block universe and robust passage’ I am again stymied.”

⁴ The views of Skow and Maudlin actually do not seem to diverge that much. Skow (2018a, 1822), for one, admits that: “I accept the block universe theory, and I also think that time passes”.

⁵ The four degrees of temporal becoming, to be outlined in this paper, are not related to the four kinds of temporal becoming, outlined in FitzGerald (1985).

This explains why Maudlin maintains the passage of time to be compatible with the BU, and Skow does not.

OUTLINE. The current paper is divided into two parts. In the first part (§1), I offer a tentative characterisation of the notion of temporal becoming. I use it to distinguish four degrees of temporal becoming and subsequently take a closer look at each form of becoming (§§1.1–1.4).

In the second part (§2), I briefly discuss the compatibility of each form of becoming with the BU. I show that absolute becoming is the only form of becoming which is truly compatible with the BU. But I argue that this form is too deflated to be worthy of the name ‘becoming’. Indeed, as far as I know, no-one actually subscribes to this view. Presentist becoming and dynamic becoming, on the other hand, are clearly incompatible with the BU. The situation is much less clear when it comes to relational becoming.

1 FOUR DEGREES OF BECOMING

TIME’S WINGED CHARIOT. Everyone is familiar with time’s transitory character. We all share the impression that time *flows* or *passes*. But does it really? Is the flow of time — or *temporal becoming* as philosophers like to call it — an objective feature of reality, or is it (merely) a subjective feature of human experience? Does temporal becoming belong to physics or to psychology? Is it part and parcel of the scientific image or of the manifest image?

In this paper I will entertain the former position. Following Norton (2010, 24), I will treat our sense of passage as reflecting “a fact about the way time truly is, objectively.” That is, even if we were not around to experience it, the passage of time would still obtain.

A first question then is: What exactly does temporal becoming consist in? According to Pooley (2013, 321), “time’s alleged passage is notoriously difficult to pin down.” The problem is that the passage of time is at once familiar and baffling (Prosser, 2016, 315). We are familiar with temporal becoming; yet, we would be hard pressed to come up with a precise definition of it. This worriment already befell Saint Augustine who confessed that “if no one asks me, I know. But if I wish to explain it to one that asketh, I know not” (Watts, 1912, 239).

PASSIVE AND ACTIVE METAPHORS. As a result, humankind has used all kinds of metaphors to capture time’s transitory aspect. Omar Khayyám’s quatrain at the beginning of this paper is but one poetic attempt at capturing time’s relentless march from past to future. The romantic poet Charles Cowded Clarke in his 1875 sonnet *The Course of Time* referred to “the vast wheel of time, That round and round still turns with onward might”, whereas George Santayana (1938, 85) compared “the essence of nowness” to fire running “along the fuse of time.”

In general, though, there seem to be two ways of expressing the passage of time (Smart, 1949):⁶

⁶ Just as with passive and active symmetry transformations, both ways of expressing the passage of time are supposed to be equivalent.

1. *Passive way*: Time is stationary and we advance through time, much like a ship advancing through the sea.
2. *Active way*: We are stationary and time streams past us, much like a river streaming underneath us on a bridge.

Eddington (1920, 51) preferred the passive view when he said that “events do not happen; they are just there and we come across them.” Weyl (1949, 116) similarly pointed out that:

Only to the gaze of my consciousness, crawling upward along the life line of my body, does a section of this world come to life as a fleeting image in space which continuously changes in time.

The lyrical poet Andrew Marvell, on the other hand, preferred the active view when he spoke of “time’s wingèd chariot hurrying near” (Craze, 1979, 317). We also speak of time flying or fleeing (*tempus fugit*), and of the relentless flow of the mighty river of time.

MAKING SENSE OF PASSAGE. Unfortunately, these metaphors remain vague and incomplete at best, or downright wrong and misleading at worst. So how is one to characterise the passage of time in non-metaphorical terms? Here is a recent attempt by Norton (2010, 24):

Time passes. Nothing fancy is meant by that. It is just the mundane fact known to all of us that future events will become present and then drift off into the past.

Smart (1949, 483) likewise said that events “approach from the future, are momentarily in the present, and then recede further and further into the past.” And here is Broad (1938, 266) expounding the very same idea:

An experience is at one time wholly in the future, as when one says ‘I am going to have a painful experience at the dentist’s tomorrow.’ It keeps on becoming less and less remotely future. Eventually the earliest phase of it becomes present; as when the dentist begins drilling one’s tooth, and one thinks or says ‘The painful experience I have been anticipating has now begun.’ Each phase ceases to be present, slips into the immediate past, and then keeps on becoming more and more remotely past.

As time passes, in other words, the history of our world unfolds. To many, this strongly suggests there being a unique set of global NOWs successively coming into being. The passage of time then refers to the movement of this objectively privileged present along the temporal dimension (more on this in §§1.3 and 1.4).

THREE PATHS TO PASSAGE. On the basis of this (admittedly still rough) characterisation of temporal becoming, Price (2011, 210) identified three paths to passage — three requirements that should be satisfied if we are to fully capture our intuitive notion of the passage of time:

- (1) *Temporal orientation*: The view that time has an objective *direction*; that it is an objective matter which of two non-simultaneous events is the *earlier* and which the *later*;

Table 1: Four degrees of temporal becoming.

Kind of becoming	Temporal orientation	Distinguished present	Dynamic flow	Tensed becoming	Dynamic becoming
Absolute	No	No	No	No	No
Relational	Yes	No	No	No	No
Presentist	Yes	Yes	No	Yes	No
Dynamic	Yes	Yes	Yes	Yes	Yes

- (2) *Distinguished present*: The view that the *present moment* is objectively distinguished;
- (3) *Dynamic flow*: The view that there is something objectively *dynamic*, flux-like, or “flow-like” about time.

FOUR DEGREES OF TEMPORAL BECOMING. In what follows, I will speak of *dynamic becoming* (or *dynamic passage*) when all of Price’s requirements are met. It should be clear, however, that weaker (deflated) notions of becoming can be obtained by satisfying only one or two of the above requirements.

One could, for instance, endow the spacetime under consideration with a temporal orientation and an objectively privileged present, without making that present move — thereby meeting requirements (1) and (2), but not (3). Or one could introduce a temporal orientation, and leave it at that — satisfying requirement (1), but not (2) and (3). Some even claim that sense can be made of temporal becoming without meeting any of the above requirements.

Clearly then, four kinds of temporal becoming can be distinguished (Table 1). A precise definition of each kind of temporal becoming will be provided further on. For the moment, suffice it to say that as you go down the list, more requirements are met, resulting in stronger kinds of becoming. We thus obtain a hierarchy of forms — or degrees — of temporal becoming, with absolute becoming the weakest, and dynamic becoming the strongest form of temporal becoming.

Each kind of temporal becoming presupposes the previous kinds. That is, relational becoming presupposes absolute becoming; presentist becoming presupposes relational becoming; and dynamic becoming presupposes presentist becoming.

The distinction between absolute and relational becoming was first made by Dorato (2006).⁷ Both absolute and relational becoming are examples of what I will call *tenseless* becoming, or B-series becoming. Presentist becoming and dynamic becoming, on the other hand, are examples of *tensed* becoming, or A-series becoming. Absolute, relational and presentist becoming are *static* (Parmenidean) forms of becoming, whereas dynamic becoming is obviously *dynamic* (Heraclitean).⁸ Once again, what Price (2011) calls real, objective becoming corresponds here to dynamic becoming.

⁷ Note that this distinction is completely unrelated to the debate on whether space and time are absolute or relational in character.

⁸ These notions will be further explained in the sections §§1.1–1.4 to come.

Unfortunately, these four kinds of becoming are often conflated in the philosophical literature. As a result, many philosophers of time and physics talk past each other, muddling an already muddled debate.⁹ In what follows, I critically discuss each kind of temporal becoming (§§1.1–1.4), before gauging their compatibility with the BU theory of time (§2).

One last remark: in order to keep the discussion focussed, I will limit myself to a study of temporal becoming in a (special or general) relativistic setting. That is, I will not analyse the nature of becoming in quantum mechanics, quantum field theory or theories of quantum gravity.

1.1 Absolute becoming

The notion of absolute becoming has been independently defended by Savitt (2002), Dorato (2002, 2006), and Dieks (2006) in an attempt to make room for temporal becoming in the BU. Compared to the other kinds of becoming, this is by far the most *deflated* form. The coming into being of an event, on this account, is nothing but its happening. “Events come into being by occurring, by happening”, holds Dieks (2006, 170), “what other coming into being could there be?” Here then is our definition of absolute becoming (see also Dorato, 2006):

Definition 1. Let $\langle \mathcal{M}, g_{ab} \rangle$ be a relativistic spacetime, and consider an event $a \in \mathcal{M}$.¹⁰ To say that a *becomes* (or comes into being) at that spacetime point means that a occurs or happens at that point.

THE DOCTRINE OF THE MANIFOLD. The notion of absolute becoming is certainly now new. It originated in Broad’s careful analysis of McTaggart’s argument for the unreality of time (Broad, 1938). Indeed, it was Broad who coined the term ‘absolute becoming’ to convey the idea that “to ‘become present’ is, in fact, just to ‘become’, in an absolute sense [...] or, most simply, to ‘happen’.”

A few years later, Williams, in his paper *The Myth of Passage* (1951),¹¹ similarly maintained that “taking place is not a formality to which an event incidentally submits — it is the event’s very being” (p. 464). Hence, according to Williams, “there is passage, but it is nothing extra. It is the mere happening of things” (p. 463). “World history”, for Williams, “consists of actual concrete happenings”, and that is all there is to the matter (p. 464).

⁹ Price (2011) concurs that his three paths to passage — and, by extension, my four degrees of becoming — “have not been sufficiently distinguished, either by defenders or critics of the notion of objective passage — a fact which has allowed the two sides to talk past one another, in various ways.”

¹⁰ A general relativistic spacetime is an ordered pair $\langle \mathcal{M}, g_{ab} \rangle$ where \mathcal{M} is a smooth, connected, n -dimensional manifold ($n \geq 2$, usually $n = 4$) and g_{ab} is a smooth Lorentzian metric on all of \mathcal{M} . Each element a of \mathcal{M} represents a spacetime point or event. Two remarks are in order. First, we are treating events in an idealized way by restricting our attention to point-events which happen at a spacetime *point*, rather than at a spacetime *region*, and thus have no spatial extension nor temporal duration. Examples of such idealized point-events include the collision of two particles, the lighting of a firecracker, the decay of an elementary particle, or an instant in the history of a photon. Second, it is useful to distinguish between *spacetime points* and *point-events*: spacetime points belong to the manifold \mathcal{M} , whereas point-events are what potentially happens at those points. A point-event, such as the collision of two particles, can of course occur at different spacetime points.

¹¹ *The Myth of Passage* was later reprinted, with minor modifications, in Gale (1968).

The quest for anything extra that would capture the *true* passage of time — whether that be something active or moving, a dynamic essence, a transitory aspect, or some other ingredient — would be an “altogether false start”, according to Williams (p. 102). There simply is nothing over and above “the spread of events in space-time” (p. 153) — nothing dynamic, nothing transitory, and nothing flux- or flow-like. Williams called this “the doctrine of the manifold”.¹²

THIN AND YAWN-INDUCING. Far from everyone is convinced by this deflationary analysis of temporal becoming. In a recent paper, Leininger (2018, 109) wrote that “this kind of passage is no more than a clock showing different times at different moments.” According to Earman (2008, 159), absolute becoming is at best “a thin and yawn-inducing” sense of becoming. Finally, in the words of Pooley (2013, 326), the “advocates [of absolute becoming] seem to be making heavy weather of facts that (almost) no one has ever denied.” What is worse, they divert the “attention from the key challenge [...], namely, that of providing [an] explanation of why we are inclined to take the ‘becoming more past’ of events as an objective feature of reality” (p. 326).

FROM ABSOLUTE TO RELATIONAL. Let me stress that as long as we consider absolute becoming, “we are abstracting from the spatial and temporal relations that an event *e* bears to other events” (Dorato, 2006, 563). As Dorato argued, even in a universe consisting of a single event, there would be absolute becoming. But as soon as more than one event is present, we can study the spatiotemporal relations between them. This brings me to the second degree of temporal becoming — relational becoming.

1.2 Relational becoming

The proponents of absolute becoming (referred to above) do not actually endorse the admittedly bare, absolute notion of becoming, as given in definition 1. Instead, they all go further by advocating a slightly stronger (but importantly different) notion of temporal becoming which I claim is more appropriately classified as relational becoming.¹³

According to Dieks (2006, 171), for example, “becoming is nothing but the happening of events, *in their temporal order*” (emphasis added). Savitt (2002, 157) similarly maintained that “true and literal passage is the *ordered* occurrence of [...] events in the manifold” (emphasis added). Williams (1951, 464), finally, concurred that the passage of time “consists of actual concrete happenings *in a temporal sequence*” (emphasis added).

A NETWORK OF HAPPENINGS. Clearly then, the idea behind all this is that spacetime is not a structureless set of unrelated events, but a spatiotem-

¹² For more on Broad’s and Williams’ conception of absolute becoming, see Savitt (2002).

¹³ Most proponents of absolute becoming have failed to distinguish absolute from relational becoming, in the way Dorato (2006) has done, and I have done here. For them, relational becoming is part of the definition of absolute becoming. Consider, for instance, Savitt (2002, 160) who maintains that “absolute becoming is the *ordered* occurrence of [...] events” (emphasis added). The accounts of absolute becoming, advocated by Dieks, Savitt and Williams, thus fall under the category of relational becoming, which seems to suggest that no one actually defends bare absolute becoming.

poral “network of happenings” (Dieks, 2006, 173). Indeed, the spacetime manifold has topological structure, affine structure and metric structure. It is in virtue of this added structure that events can be temporally related to one another, such that some events are simultaneous, some are earlier and some later (and some perhaps unrelated) — yielding a temporally ordered web of events.

The temporal ordering of events is carried out via an asymmetric, transitive, binary relation such as the earlier-than relation E or later-than relation L . Of course, the order thus obtained need not be *total*. Classical Newtonian spacetime can be foliated into simultaneity hypersurfaces which are totally ordered. But in special and general relativity, the lightcone structure only imposes a *partial* order on all events, such that for any event $a \in \mathcal{M}$, all events p in its past lightcone are earlier than a (pEa), all events f in its future lightcone are later than a (aEf), and all events o outside the two lightcones are not temporally ordered with respect to a .

For the proponents of relational becoming, this is all we need to make sense of the passage of time. Those events which are earlier than a have already become; those which are later than a have not yet become. Here then is the definition of relational becoming (see also Dorato, 2006):¹⁴

Definition 2. Let $\langle \mathcal{M}, g_{ab} \rangle$ be a relativistic spacetime, and consider a pair of events $a, b \in \mathcal{M}$. Let B be a two-place relation of becoming. To say that a has become for b means that a and b are related by B such that aBb .

TEMPORAL ORIENTATION. Typically, the becoming relation B is taken to be the earlier-than relation E . However, in order for the earlier-than relation E to exist, and to be used to temporally relate the web of events, the spacetime under consideration must be *temporally oriented*. That is, at every point of spacetime, the past-to-future direction has to be specified. If this were not the case, then there would be no way to tell for any pair of timelike separated events $a, b \in \mathcal{M}$ whether aEb or bEa . That is to say, without a temporal orientation, a and b cannot be temporally ordered.¹⁵

In short, since relational becoming assumes there to be a temporal order, it must assume spacetime to be temporally oriented. Nothing new is being said here. Yet, it is surprising how little attention this well-known fact has received in the philosophical literature.

B- AND C-THEORETIC BECOMING. One exception is Maudlin, who has stressed the need of a temporal orientation for relational becoming in terms of the B- and C-series of McTaggart (1908).¹⁶ In the A-series, it will be recalled, events are ordered as past, present and future.¹⁷ In the B-series,

¹⁴ Note that what Skow (2015) calls “anemic” passage is actually very close (if not identical?) to relational becoming as defined here (see also Leininger (2018)). Indeed, Skow (2018a, 1823) subscribes to the definition of anemic passage as given in Deasy (2018) according to which “the passage of time is anemic iff the following is true: if there is a time later than this one, then in virtue of this fact time is passing”.

¹⁵ Without an orientation, one could, at most, say that a and b are timelike, rather than spacelike or lightlike, separated.

¹⁶ McTaggart’s paper *The Unreality of Time* later reappeared as chapter 33, *Time*, in his 1927 volume *The Nature of Existence* (McTaggart, 1927).

¹⁷ Events are said to possess intrinsic, monadic temporal properties of being present, or being past or future to differing degrees.

events are ordered as earlier-than, later-than and simultaneous-with.¹⁸ In the C-series, finally, no such temporal asymmetry is posited, and events are ordered via a ternary betweenness relation, rather than via the binary earlier-than or later-than relation. Hence, what makes the C-series fundamentally unlike the A- and B-series is that it lacks a temporal orientation.¹⁹ Hence, in developing his account of relational becoming, Maudlin (2007, 126) argues:

The theory of time's passage I defend focuses on the B-series: all events are ordered by a transitive, asymmetrical relation of earlier and later. [...] Any theory that denies a fundamental asymmetric relation of earlier than (or later than), and hence denies an intrinsic direction of time, ought not to be called a B-series theory but rather a C-series theory. So I am not arguing for an A-series theory over a B-series theory, I am arguing for a B-series theory over a C-series theory.

Two types of relational becoming can thus be distinguished: *B-theoretic* versus *C-theoretic* relational becoming. Whereas C-theoretic relational becoming requires spacetime to be temporally *orientable*, B-theoretic relational becoming requires spacetime to be temporally *oriented*. To the best of my knowledge, no one currently advocates the C-theoretic version. Even Dieks, Savitt and Williams above assume spacetime to be temporally oriented. So if no one actually subscribes to either absolute becoming (as argued above) or C-theoretic relational becoming, then B-theoretic relational becoming would seem to be the weakest form of temporal becoming currently taken seriously in the literature.

ADDED STRUCTURE. One precondition for the existence of a *temporal orientation* is that the relativistic spacetime under consideration be *temporally orientable*. But although the temporal orientability of a relativistic spacetime $\langle \mathcal{M}, g_{ab} \rangle$ is a *necessary* condition for that spacetime to be temporally oriented, it is not a *sufficient* condition (Price, 2011). A temporally orientable spacetime $\langle \mathcal{M}, g_{ab} \rangle$ can always be oriented in one of two ways. Neither of these orientations is objectively right or wrong. Indeed, since the metric g_{ab} cannot distinguish between future-directed and past-directed timelike 4-vectors, the choice of a temporal orientation amounts to the addition of *extra structure* to the relativistic spacetime under consideration. I will make this notationally explicit by denoting a non-temporally oriented relativistic spacetime as $\langle \mathcal{M}, g_{ab} \rangle$ and a temporally oriented one as $\langle \mathcal{M}, g_{ab}, \uparrow \rangle$.

All too often, this extra structure is merely postulated without explaining where it comes from. In a recent paper defending the objectivity of temporal becoming, for example, Savitt (2018, 2) acknowledges that the “radical difference between the past and the future” is a basic feature of the passage of time. But Savitt has “little to say about this feature”. He thus simply assumes “that spacetime is represented by an orientable manifold and that *this manifold has, somehow, acquired an orientation*” (emphasis added). Again, in an attempt to explain the passage of time from a B-theoretical perspective,

¹⁸ Whereas the A-properties are constantly changing (at least on the standard view), the B-relations are eternal.

¹⁹ To put it differently, whereas the B-series is *anisotropic*, the C-series is *isotropic*. The former represents a *directed* order; the latter only a *serial* order (Reichenbach, 1956, 26-7).

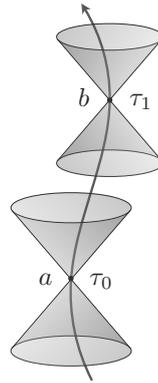


Figure 1: Diagram of time-oriented Minkowski spacetime $\langle \mathcal{M}, \eta_{ab}, \uparrow \rangle$ with two events $a, b \in \mathcal{M}$ and their respective lightcones.

Dieks (2012, 112) just accepts the temporal “asymmetry [between the past and the future] as given.” Finally, in his *Precis of Objective Becoming*, Skow (2018b, 1788) writes that according to the BU theory, “at the very least some spacetime points are later than others, so that among the relations spacetime points bear to each other are temporal relations.”

The presupposition, however, that all temporally orientable spacetimes are, as a matter of course, temporally oriented, is not as innocent as these authors make it sound. As Earman (1974, 19) pointed out, it remains an open question whether our world is equipped with a temporal orientation or not. I will return to this point in §2.

WHERE IS THE WHIZ AND GO? Before we continue, let us briefly take stock of what we have seen so far by considering the pair of events $a, b \in \mathcal{M}$ in Figure 1. Absolute becoming says that:

1. Since a occurs at τ_0 , it becomes at τ_0 ;
2. Since b occurs at τ_1 , it becomes at τ_1 .

Relational becoming (of the B-theoretic type) additionally says that

3. Since $\tau_0 < \tau_1$, a occurs before b ; hence, a has become for b .

In short, $aEb \rightarrow aBb$. All of these facts can of course be represented in a traditional spacetime diagram, such as Figure 1.

To most proponents of temporal becoming, however, the above account is still too modest and weak. Where, they will ask, is “the whiz and go” (Savitt, 2002, 162)? How can a static representation, such as Figure 1, capture the dynamic unfolding of our world?

Savitt (2002, 163) responded (correctly in my opinion) that one should not confuse a “static representation with a representation of stasis.” That is, “we do not need an animated picture to have a picture of animation.” Dieks (2006, 172) concurred that “the fact that the block diagram [...] does not ‘flow’ is irrelevant for the status of what is being depicted.” Maudlin (2007, 140), finally, joined forces in noting that “mathematical objects are, in their own nature, ‘static’.” Hence, it is only natural that we find them inadequate to represent the passage of time, but in Maudlin’s opinion this “apparent inadequacy must be an illusion” (p. 142).

DOES A STACK OF PAPERS BECOME? Nonetheless, the worry remains that the mere presence of a temporally ordered set of events is not sufficient to capture the passage of time. After all, a stack of papers can be ordered too (e.g. a book with pages running from 1 to some higher number), but surely dixit Dieks (2006, 170) “the papers do not come into successive existence by virtue of this.” Likewise, events can be spatially ordered, but this does not seem sufficient to justify the existence of spatial becoming.

So, how is a temporally ordered set of events different from a spatially ordered one, or from a linearly ordered stack of papers? Here, the answers by the advocates of relational becoming diverge. For Dieks (2006), the answer relies in the fundamental difference between space and time. Even in relativity theory, where “space by itself, and time by itself, are doomed to fade away into mere shadows” (Lorentz et al., 1952, 75), the spatial dimensions remain distinct from the temporal one. This is made explicit, for instance, in the $(-, +, +, +)$ signature of the metric tensor which assigns a $+$ to the spatial coordinates and a $-$ to the temporal coordinate.²⁰

Maudlin (2007, 109) likewise concedes that “the passage of time connotes *more* than just an intrinsic asymmetry” (emphasis added). There is more to the passage of time, in Maudlin’s view, than the mere presence of a temporal orientation. For Maudlin (2007, 110), there is the additional aspect of “one state ‘coming out of’ or ‘being produced from’ another”. Earlier states produce later ones; not the other way round. There is, in other words, an important asymmetry in our explanatory scheme:

The [...] final state is accounted for as the *product of an evolution from a [...] initial state* in a way that the initial state cannot be explained as a product of evolution from a [...] final state. (Maudlin, 2007, 133)

Those who remain unconvinced that relational becoming fully captures the transitory aspects of time should look for ways to expand the notion. This will lead to the next two degrees of temporal becoming: presentist becoming and dynamic becoming. Before we look at these notions, however, let me conclude this section by considering two examples of relational becoming. The first one was proposed, a long time ago, by Stein (1991) (§1.2.1); the second one is currently endorsed by Maudlin (2002, 2007) (§1.2.2).

1.2.1 Steinian becoming

At first sight, the theory of special relativity seems rather hostile to the idea of temporal becoming. Indeed, Gödel (1949) famously argued *against* temporal becoming on the basis of the relativity of simultaneity (see also §1.3). Rietdijk (1966), Putnam (1967) and Maxwell (1985) independently reached much the same conclusion. Call this the RPM argument *against* becoming. An important counterargument, however, was developed by Stein (1968, 1991), and was further generalized by Clifton and Hogarth (1995).²¹ Call this the SCH argument *for* becoming.

²⁰ Alternatively, one might choose to use a metric whose signature is $(+, -, -, -)$. Which signature is selected, is a matter of convention. What is important is that in both cases the signature clearly differentiates the spacelike from the timelike directions.

²¹ Stein (1968) was a direct response to Rietdijk (1966) and Putnam (1967), whereas Stein (1991) was provoked by Maxwell (1985).

THE SCH ARGUMENT. In essence, RPM argue for the BU theory of time, according to which the future is ontologically determinate (fixed, actual); SCH argue that the future is ontologically indeterminate (open, potential). Since the passage of time supposedly turns an indeterminate future into a determinate present, temporal becoming requires an open future. Hence, RPM (indirectly) argue *against* temporal becoming, whereas SCH argue *for* temporal becoming. To be specific, SCH showed that time-oriented Minkowski spacetime *is* compatible with an objective notion of becoming.

THE BECOMING RELATION. Stein (1991) considers time-oriented Minkowski spacetime $\mathcal{M} = \langle \mathbb{R}^4, \eta_{ab}, \uparrow \rangle$ and introduces a two-place relation B among the elements of \mathcal{M} , where B stands for ‘has become for’. That is, B is a binary relation between spacetime points or events. Then aBb is shorthand for ‘event a has become for event b’. Stein furthermore requires B to satisfy the following (natural) assumptions which he deems necessary for a notion of objective becoming:

1. B is definable from time-oriented metrical relations;
2. B is reflexive, *i.e.* a has already become for a (aBa);
3. B is transitive, *i.e.* $aBb \wedge bBc \rightarrow aBc$;
4. B is non-universal, *i.e.* for any point b, there is a point a such that $\neg aBb$;
5. aBb holds whenever a is in the causal past of b, *i.e.* $aJ^-b \rightarrow aBb$.

REMARKS. Requirement 1 ensures the objectivity of the becoming relation by demanding that B remains invariant under all automorphisms of \mathcal{M} preserving the temporal orientation \uparrow . Requirements 2 and 3 should be self-explanatory. Requirement 4 demands that B be different from the universal relation U. After all, the idea of becoming is that for any event b, some events have become (constituting the determinate past), whereas other events have not yet become (constituting the indeterminate future). Since U holds between any pair of events, no event would be indeterminate for b; there would be no open future, and thus no becoming. Hence, by requiring B to be non-universal, Stein’s theorem does not actually *prove* that there is temporal becoming; it merely shows temporal becoming to be *compatible* with Minkowski spacetime (Dorato, 1996). Requirement 5, finally, can be rewritten in terms of the relation of past causal connectibility κ_p , such that $a\kappa_p b \rightarrow aBb$.

STEIN’S THEOREM. On the basis of this, Stein (1991) proceeds to prove the uniqueness of the becoming relation B. To be specific, Stein shows that if B satisfies all constraints above, then B reduces to (is co-extensional with) the relation of past causal connectibility κ_p . This, then, is Stein’s theorem:

Theorem 1. *Let B be a binary relation among the elements of time-oriented Minkowski spacetime $\mathcal{M} = \langle \mathbb{R}^4, \eta_{ab}, \uparrow \rangle$, where B stands for ‘has become for’, and where B satisfies the constraints 1 to 5 above. Then for any pair of events a and b in \mathcal{M} , the following holds:*

$$aBb \iff a\kappa_p b.$$

That is, a has become for b iff a is in the causal past of b. □

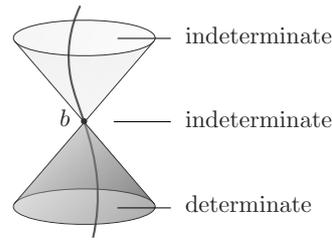


Figure 2: The past, present and future for b according to Steinian becoming.

This shows, contra RPM, that “at each stage, the entire history of the world is separated into a part that has already become [...] and a part that is not yet settled” (Stein, 1991, 148). Indeed, according to theorem 1, all events in the past lightcone of b are determinate; all events outside the past lightcone of b are indeterminate (Figure 2).

CHALLENGING THE STATUS QUO. According to Clifton and Hogarth (1995, 356), “Stein’s proof has settled the issue [...] in favour of the possibility of objective becoming” in a special relativistic setting. Indeed, “the idea that Stein conclusively refuted Putnam et al [...] seems to have achieved the status of conventional wisdom”, writes Callender (2000, S592). These statements have to be tempered in two respects.

First, Stein’s notion of objective becoming aspires to be a form of relational becoming. The becoming relation B , after all, fails to meet requirements 2 and 3 referred to in §1. That is, Stein’s becoming relation fails to pick out a distinguished present. For any arbitrary spacetime point $b \in \mathcal{M}$, Stein’s relation tells you which events have become relative to b , and which have not. But it doesn’t tell you which event is present now. Second, there is nothing dynamic or flow-like in Stein’s account of becoming. So to the extent that Stein indeed proved “the possibility of objective becoming”, this only applies to relational becoming, *not* to the stronger forms of presentist and dynamic becoming.

Second, even as a form of relational becoming, Stein’s becoming relation is problematical for various reasons. Callender (2000, 2017) and Bigaj (2008) have raised important objections, but I want to draw the reader’s attention to yet another one. Notice that in their study of relativistic becoming, SCH assume Minkowski spacetime to be temporally oriented. That is, instead of working with Minkowski spacetime $\langle \mathbb{R}^4, \eta_{ab} \rangle$ as such, SCH consider the beefed-up structure $\langle \mathbb{R}^4, \eta_{ab}, \uparrow \rangle$. After all, argue Clifton and Hogarth (1995, 359), a “minimal distinction between the past and the future is needed before one has any hope of driving an ontological wedge between them.” Stein (1991, 148) similarly maintains that “since our issue is the coherence of a notion of *becoming*, we must, of course, postulate a distinguished *time-orientation*” (emphasis in original).

However, as I have argued before, it is far from clear whether all temporally orientable spacetimes come equipped with a temporal orientation. I will return to this issue at the end of my paper (§2).

1.2.2 Maudlinian becoming

In his review of Skow's *Objective Becoming*, Maudlin (2018, 1813) admits regarding himself (and being regarded by others) "as holding an extremely strong view about [...] the passing of time". "I think that time passes", he writes (p. 1808). "I think that the passage of time is a fundamental characteristic of it: if something does not pass, then that thing is not time."²²

The question of interest, however, is which form of temporal becoming Maudlin has in mind when speaking of the passage of time. For Maudlin (2007, 109), "The passage of time is deeply connected to the problem of the direction of time, or time's arrow." By the direction of time, Maudlin (2007, 109) means "an irreducible intrinsic asymmetry in the temporal structure of the universe" (see also §2). Indeed, according to Maudlin (2017, 78):

The essence of time is successiveness, one thing happening after another in a fixed order. Newton took the ordered entities to be moments of universal time, each one spread out over all of space. Relativity takes them instead to be events, and the order to be a partial order. But the primary notion of successiveness and asymmetrical ordering remains.

I think this quite clearly puts Maudlin in the camp of (B-theoretic) relational becoming. In a special relativistic setting (with a temporal orientation), events occur in successive order along timelike worldlines. For Maudlin (2017, 78-9) the flow of time does not get more dynamical than this: "The temporal aspect of space-time is dynamical: events along a single worldline occur in successive temporal order. Even in relativity, time passes."

Nowhere does Maudlin mention a distinguished present ("I'm sure I'm no sort of presentist!" exclaims Maudlin, 2018, 1809), suggesting he does not subscribe to a form of presentist becoming. Finally, Maudlin (2018, 1811) is very sceptical about the possibility of a temporal flow or flux of time (and rightly so, I think) as this would require the introduction of a *second-order time* or *metatime* (see also §1.4): "to attribute [a flow or flux] to time is to force the postulation of the second-order time." But such a notion would quickly lead to vicious circularity or vicious regress. Hence, Maudlin (2018, 1808) concludes: "I do not believe in any meta-time or hyper-time or second-order time." This suggests he does not subscribe to a form of dynamic becoming either.

1.3 Presentist becoming

At the beginning of §1, I outlined three requirements for a full-blown account of objective becoming. The second requirement was the presence of an objectively distinguished present. I will speak of *presentist becoming* when such a present exists.

Definition 3. Let $\langle \mathcal{M}, g_{ab} \rangle$ be a relativistic spacetime. To say that there is *presentist becoming* means that $\langle \mathcal{M}, g_{ab} \rangle$ is endowed with a temporal orientation, and that there is an objectively distinguished present.

²² Maudlin (2018, 1809) regards the passage of time as *critical* of time: "time is exactly that aspect of physical reality that passes."

According to Leininger (2018, 111), it is the existence of a NOW that differentiates A-theories from B-theories. Hence, since absolute becoming and relational becoming lack an objectively privileged now, they are both B-theories. Presentist becoming, on the other hand, is an A-theory, since it postulates the existence of one, and only one, moment that is privileged as being the present moment or NOW. Leininger (2018, 111) calls this the *A-Present Thesis*. According to presentist becoming, reality is tensed in the sense that each event is either past, present or future. Hence, any description of reality will remain incomplete, on this view, as long as we fail to specify which time is present.

PARMENIDEAN PRESENTISM. By far the most popular account of presentist becoming is *presentism*. On this (ontologically austere) view, only the events constituting the present moment are singled out as being real. Past events were real but are no longer; future events will become real but are not yet. The presentist, as a consequence, takes the world to be three-dimensional. Some prominent advocates of presentism are Arthur Prior, John Bigelow, Dean Zimmerman, Peter Ludlow, Thomas Crisp, Ned Markosian, and Trenton Merricks (Sullivan, 2012).

Usually, on such presentist accounts, time is assumed to pass: present events disappear into the past as future events come into existence, leading to a succession of present moments or a moving NOW. However, this is a separate claim, not logically entailed by the belief in an objective present. Leininger (2018, 111), for instance, refers to this as the *A-Change Thesis*, to draw the contrast with the *A-Present Thesis* referred to above.

Here, I do not (yet) want to assume this dynamic aspect of time. After all, as soon as we set the NOW in motion, we are no longer dealing with *presentist* becoming, but with *dynamic becoming*, to be discussed in the next section. For the moment, then, I will assume the present to be static. That is, I will assume that the state of the world does not change with time. Or, to put it yet differently, I will assume that the *A-Present Thesis* obtains, but not the *A-Change Thesis*. Price (2011, 211) refers to this position as *presentism-without-change*. Monton (2006, 264) calls it *Parmenidean presentism*, contrasting it with (the more natural) *Heraclitean presentism*.

THE STATIONARY SPOTLIGHT. But Parmenidean presentism is not the only possible account of presentist becoming. Another example of presentist becoming (albeit a less popular one) can be found in a particular version of the *moving spotlight* (MS) theory of time.²³

The MS theory of time combines ideas from both the BU theory and the A-theories of time. Like the BU theory, it holds that all past, present and future events are real. The world, as a consequence, is four-dimensional. This view is called *eternalism* and finds a natural representation in the BU. Unlike the BU theory, these events do not coexist on an equal ontological footing. The present moment “glows with a special metaphysical status” (Skow, 2009, 666), as if being illuminated by a spotlight.

Usually, the spotlight is assumed to move from earlier to later times, such that which moment is being illuminated changes. Broad (1923, 59) likened

²³ The *growing block* theory of time provides yet another account of presentist becoming, but will not be discussed in this paper. Advocates of the growing block theory include C. D. Broad, Robert Adams, Michael Tooley, and Peter Forrest (Sullivan, 2012).

it to the spotlight “from a policeman’s bulls-eye traversing the fronts of the houses in a street.” But here again, I do not (yet) want to assume this dynamic aspect. Our focus here, then, is on the *stationary spotlight* (SS) theory, not on the *moving spotlight* theory (Wilson, 2018). Price (2011, 212) calls this *frozen-block presentism*.

GLOBAL BECOMING. How plausible are Parmenidean presentism and the stationary spotlight theory of time? For a start, neither theory has ever been seriously entertained. Two problems might explain this fact:

1. The problem of how to distinguish the present moment;
2. The problem of keeping the present moment stationary.

Let us tackle these in turn, starting with the first problem. The passage of time has typically been associated with a succession of global *nows*. Each such cosmic *now* extends across the entire Universe, and groups all globally simultaneous events into one hypersurface of simultaneity.

However, in view of the *relativity of simultaneity*, observers moving with different (uniform) velocities relative to one another, each have their own set of universal *nows*. Given the principle of relativity, however, no observer is privileged. Hence, there is no objectively preferred way of foliating spacetime into spacelike hypersurfaces. Gödel (1949, 558) notoriously argued along these lines:

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

Gödel’s problem is only aggravated by the *conventionality of simultaneity*, according to which the notion of distant simultaneity loses its objective meaning even for one and the same observer. That is to say, which spacelike separated events an observer deems to be simultaneous with his *HERE* and *NOW* depends on a *convention* (such as the choice of the Reichenbach synchronisation parameter ϵ , with $0 < \epsilon < 1$).

As if the situation is not already bleak enough, there is the additional fact that certain relativistic spacetimes (such as Gödel’s infamous rotating Universe) do not even admit a foliation into spacelike hypersurfaces. This then is the final nail in the coffin of an already foundering attempt at establishing global becoming.

LOCAL BECOMING. One way out of this problem is by giving up the notion of global becoming altogether, and postulating a form of *local becoming* to make it compatible with relativity theory.²⁴ This view has been developed

²⁴ There are other ways out. First, as to Gödel’s rotating Universe, one might hold that such exotic spacetimes are logically and mathematically possible, but not physically. Second, even though Minkowski spacetime does not posit a preferred foliation, there are (highly symmetric) general

by Dieks (1988, 2006) in particular. The trouble with global becoming is that it relies on a preferred foliation, which yields a *total* temporal order, as in classical Newtonian (or neo-Newtonian) spacetime. But in relativistic spacetimes, the temporal order is only *partial*.

Dieks' proposal then is to reformulate the notion of becoming in a way that does not make reference to a universal NOW. This can be done, in a first step, by restricting our attention to the history of a single particle along its worldline. The proper time imposes a total order among the events on this worldline. By singling out one event as NOW, the history of the particle is thus divided in a past, present and future part. This assignment of a local NOW should now be carried out for every particle in the Universe, taking care however that the NOW of one particle is never inside the past lightcone of any other particle.

One problem remains though. According to Dieks (1988, 459), "it is not possible to single out any particular moment as the 'now' on the basis of the laws of physics." Notice that this problem also applies to global becoming. Even if we could agree on a preferred foliation, the question remains how to single out one of these hyperplanes as representing the NOW.

TROUBLE IN BROAD STREET. The problems keep piling up. Supposing for a moment we successfully generalized the pre-relativistic notion of a universal NOW to properly apply in a relativistic setting, and assuming that we found a way to single out the distinguished NOW in an objective way, yet another problem remains.

Both the stationary spotlight theory and Parmenidean presentism postulate a stationary present. But in doing so, we seem to have "thrown out not just the baby, but almost the entire bathroom", writes Price (2011, 212). "It is as if we've built just one house in 'Broad Street'." That is, "we seem to have lost the materials for a realist view of passage, change, or temporal transition." What is missing here, in other words, is an element of flux; we want the NOW to move from one instant to another. But for this we have to climb yet another rung up the temporal becoming ladder.

1.4 Dynamic becoming

According to most proponents of robust becoming, one important element is still missing, namely Price's third requirement that there be "something objectively *dynamic*, flux-like, or 'flow-like' about time" (see §1). Adding such an element to our account of temporal becoming yields *dynamic becoming*.

Definition 4. Let $\langle \mathcal{M}, g_{ab} \rangle$ be a relativistic spacetime. To say that there is *dynamic becoming* means that $\langle \mathcal{M}, g_{ab} \rangle$ is endowed with a temporal orientation, a distinguished present, and a dynamic flow.

In dynamic becoming, both the *A-Present Thesis* and the *A-Change Thesis*, referred to in §1.3, obtain. That is, not only is there a distinguished present or NOW, but what moment is NOW changes, leading to a succession of NOWs. It is this changing NOW, above anything else, that is supposed to capture

relativistic spacetimes which do admit of a natural foliation. Third, in quantum mechanics a foliation seems required in order to account for the observed violations of Bell's inequality. Finally, a notion of absolute simultaneity might be added to special relativity, as in the neo-Lorentzian interpretation.

the fact (referred to at the start of §1) that events become ever more past. Allow me to reiterate the point that this change in NOW is not perspectival; it is not a consequence of our own subjective perspective. Rather, as Norton (2010, 24) stressed, “the fact of passage obtains independently of us;” it is a mind-independent process.

HERACLITEAN PRESENTISM. The account of dynamic becoming preferred by most is *Heraclitean presentism*. Like its stationary analogue, Parmenidean presentism, it holds that only present events are real. Unlike Parmenidean presentism, it maintains that the present does not abide, but constantly shifts, leading to a succession of presents. This is in line with the Heraclitean aphorism *παντα ρει*, *everything flows*. Or in the words of Heraclitus himself (as translated by Wheelwright, 1959, 29):

Everything flows and nothing abides; everything gives way and nothing stays fixed. You cannot step twice into the same river, for other waters are continually flowing on.

THE MOVING SPOTLIGHT. The *moving spotlight* (MS) theory of time was first articulated by Broad (1923), and is considered one of the most obscure accounts of dynamic becoming, combining (as we saw in §1.3) elements from both the A- and B-theories of time.²⁵ As the spotlight moves, different regions of the spacetime manifold light up and become present. However, unlike Heraclitean presentism, the change in what time is present is not accompanied by a change in what exists (on the eternalist MS view, after all, all events exist). My aim here is not to enter into any more detail with regard to either presentism or the MS theory of time, except to briefly raise two (familiar) worries with respect to the moving NOW conception.

ONE SECOND PER SECOND. The first worry is about the rate at which the NOW moves. It seems that time passes at a rate of one second per second (or one hour per hour, or one year per year). To some, such as Price (1996) and Tallant (2016), this answer is nonsensical; to others, such as Maudlin (2007, 2017), there is nothing objectionable about this answer.²⁶

METATIME. The second worry is the notorious ‘two times’ objection (Pooley, 2013). Ordinary movement is defined as change in spatial position with respect to time. But for time itself to move, it seems there should be some second-order time (or *metatime*, or *hypertime*) with respect to which we could measure its movement. On the MS view, for instance, which moment in ordinary time is being illuminated by the spotlight, depends on which metatime it is. That is, at each point T of metatime, only one time t is NOW. Furthermore, at Later metatimes $T' > T$, the NOW will have moved to later times $t' > t$.²⁷

Whether or not one is prepared to bite the bullet and postulate a second temporal dimension, the worry remains that “the multiplication of times will not stop at two” (Maudlin, 2018, 1811). After all, in asking ourselves how fast metatime flows, one might be forced to postulate a third temporal

²⁵ Skow’s *Objective Becoming* takes the MS theory as its focus, see Skow (2015). For another book-length treatise on the MS theory, see Cameron (2015).

²⁶ See Prosser (2016) for more references on this topic.

²⁷ Notice that one is forced to assume metatime to be temporally oriented as well.

dimension (a *metametetime*). But this of course threatens to generate an infinite regress, without an obvious way of halting it.

2 BLOCK UNIVERSE COMPATIBILITY

Some, if not most, assume the BU theory of time to be incompatible with temporal becoming. The static block, it is said, fails to capture the dynamic passage of time (Earman, 2008). Others, such as Maudlin, do not see such problem. Still others propose a variety of ways to make the block compatible with becoming. The goal of this section is to offer some clarification by gauging the compatibility of the BU with each of the four degrees of temporal becoming discussed in §§1.1–1.4. Two forms of compatibility need to be considered here:

1. Compatibility of becoming with the BU ontology as such;
2. Compatibility of becoming with a broadened BU ontology.

In the former case, the BU ontology already comes built-in with some form of becoming. That is, the BU package (and the spatiotemporal structure posited by it) already contains becoming as an ingredient. In the latter case, the BU ontology is too thin to account for becoming. Here, the BU package first has to be expanded before room can be made for becoming. For lack of better terms, I will henceforth speak of becoming being (respectively) BU-compatible and BU⁺-compatible. As a first step, then, let us briefly unpack the BU ontology.

THE BU ONTOLOGY. The BU ontology posits a four-dimensional manifold \mathcal{M} of events, along with a spatiotemporal metric g_{ab} .²⁸ Although the resulting spacetime (\mathcal{M}, g_{ab}) is assumed to be temporally orientable, no temporal orientation is provided (see §1.2). All events are ontologically on a par; no time is metaphysically privileged. In particular, there is no distinguished present or NOW, let alone an additional time dimension.

ABSOLUTE BECOMING. Given its deflationary character, it should come as no surprise that absolute becoming is BU-compatible. After all, the proposal is to equate the coming into being of an event with its happening. Hence, argues Dieks (2006, 170), “since everything that happens is recorded in the block universe diagram, ‘coming into being’ is also fully represented. There is no need to augment the block universe in any way.” Indeed, “the four-dimensional picture *already contains* becoming” (Dieks, 2006, 174, emphasis in original).

One important caveat is to be noted though. As I have argued in §1.2, what Dieks and others have in mind when discussing the relative merits of absolute becoming, is actually a form of relational becoming. And while Dieks is perfectly right to maintain the BU-compatibility of absolute becoming, this need not necessarily hold true for relational becoming too.

RELATIONAL BECOMING. In Maudlin’s opinion, there is no question about the BU-compatibility of (B-theoretic) relational becoming. “I believe in a

²⁸ In the case of special relativity, for instance, $\mathcal{M} = \mathbb{R}^4$ and $g_{ab} = \eta_{ab}$, the Minkowski metric.

block universe”, writes Maudlin (2007, 109). “But I also believe that time passes, and see no contradiction or tension between these views.” Indeed, “the four-dimensional universe is a single entity of which the *passage* of time [...] is an ingredient” (emphasis in original).²⁹ Stein (1991, 148) similarly concurs that “a notion of ‘real [*i.e.* relational] becoming’ can be coherently formulated in terms of the structure of Einstein-Minkowski space-time.” Stein (1991, 147) thus regards his becoming relation B as “uniquely appropriate to the special theory of relativity.”

However, relational becoming requires a temporal orientation, and while I agree with Maudlin (2007, 118) that “the admission of an orientation to space-time is not, *per se*, wildly at odds with present physical theory”, the question is whether such an orientation is built into the BU package, or has to be added to it. That is, the question is whether relational becoming is BU- or BU⁺-compatible.

As I explained in this paper, most proponents of relational becoming remain surprisingly silent on this issue. Stein (1968, 1991), Clifton and Hogarth (1995), for instance, simply *assume* the BU to be temporally oriented. But according to Price (1996), time is not endowed with an intrinsic direction or arrow at all (see also Price, 2011). Horwich (1987) likewise maintains that “time itself is intrinsically symmetric.” Such a view is of course not new. Boltzmann, in his *Lectures in Gas Theory* of 1896, already played with the idea that “the two directions of time are indistinguishable, just as in space there is no up or down.”

THE TIME DIRECTION HERESY. The big exception here is Maudlin (2002, 2007). Maudlin holds a minority position in this debate, championing the view that the past-to-future direction *is* distinguishable from the future-to-past direction. According to Maudlin (2017, 78), the passage of time is “a metaphysically fundamental characteristic that cannot be further analyzed [...] into simpler or more basic components.” This view is no different from Newton (1934) who claimed that “time, of itself, and from its own nature, flows equably without relation to anything external.”

Since Maudlin’s view on becoming is relational (as argued in §1.2.2), this claim amounts to taking the direction of time as fundamental. That is, spacetime comes hardwired with an arrow of time. For Maudlin, this intrinsic asymmetry of time is “a fundamental, irreducible fact about the spatio-temporal structure of the world” (Maudlin, 2007, 107). This makes Maudlin the staunchest promotor of what Earman (1974, 20) has called *The Time Direction Heresy* — the view that the “temporal orientation is an intrinsic feature of space-time which does not need to be and cannot be reduced to nontemporal features”.

Like Aristotle’s unmoved mover, the direction of time is taken to be the ungrounded grounder for all other asymmetric processes. The causal arrow, for example, “is itself parasitic on a fundamental asymmetry of time”, dixit Maudlin (2012, 166). The same holds true for the thermodynamic arrow, which according to Maudlin (2012, 167) “presupposes a time direction”. In summary then, for Maudlin the arrow of time is the master arrow which explains all other arrows. It is the asymmetry *of* time that explains the asymmetries *in* time, not the other way round.

²⁹ Or again: “The belief that time passes, in this [relational] sense,” writes Maudlin (2007, 108), “has no bearing on the question of the ‘reality’ of the past or the future.”

Notice that this also explains why Maudlin is able to subscribe to both a BU ontology and the passage of time. “I believe I am committed to both a block universe and robust passage”, writes Maudlin (2018, 1809), where ‘robust passage’ should be interpreted as B-theoretic relational becoming.

TENSED BECOMING. When it comes to the compatibility of presentist and dynamic becoming, both can be treated together. For a start, it should be clear that Parmenidean and Heraclitean presentism are incompatible with the BU, since they postulate a fundamentally different ontology according to which only present events are real, whereas in the BU both past, present and future events are real.

The question therefore is whether the stationary and moving spotlight theories of time are compatible with the block. Given that the BU theory does not postulate a distinguished present nor a supertime, both the SS and MS theory are BU-incompatible. Of course, many have claimed that they can be made BU⁺-compatible, via the addition of, say, a preferred foliation and/or a second-order time.

CONCLUSION. In this paper, I distinguished four degrees of temporal becoming: (1) absolute becoming, (2) relational becoming, (3) presentist becoming and (4) dynamic becoming. The higher the degree, the stronger the form of becoming and, I argued, the less compatible with the BU ontology.

I am of the same mind as Earman (2008, 159) who finds absolute becoming too “thin and yawn-inducing” to be worthy of the name becoming. This fact, I believe, also explains why even the proponents of absolute becoming (such as Dieks, Savitt and Williams) actually endorse a stronger relational form of becoming. When it comes to presentist and dynamic becoming, the barren landscape of absolute becoming makes way for a mine field of problems, too big in my opinion to be convincingly overcome. In view of all this, the prospects for temporal becoming in a BU ontology are pretty bleak. There is, after all, only one form remaining of temporal becoming, namely relational becoming.

I showed that relational becoming is either BU- or BU⁺-compatible, depending on whether the temporal orientation is intrinsically given. According to Maudlin’s primitivist approach, the temporal orientation of our world is primitive. This renders (B-theoretic) relational becoming BU-compatible, and explains why Maudlin can uphold both the BU theory of time and the passage of time. Skow’s view on robust passage, on the other hand, corresponds to a form of dynamic becoming which is clearly BU-incompatible.

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