The Flow of Time*

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Abstract

I distinguish three views, a defence of any one of which would go some way towards vindicating the view that there is something objective about the passage of time: (i) the view that the *present moment* is objectively distinguished; (ii) 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;* (iii) the view that there is something objectively *dynamic,* flux-like, or "flow-like" about time. I argue that each of these views is not so much false as doubtfully coherent. In each case, it turns out to be hard to make sense of what the view *could be,* at least if it is to be non-trivial, and of use to a friend of objective passage. I conclude with some remarks about avenues that seem worth exploring in the philosophy of time, when we are done with trying to make sense of passage.

1 Introduction

Time seems to have a transitory character. We have the impression that it *flows,* or *passes.* From here, well-worn paths of philosophical enquiry lead in two directions. One seeks to regard this aspect of the human experience of time as a reflection of the nature of time itself. The other treats it as merely a feature of human experience, requiring a psychological rather than a metaphysical explanation.

In this chapter I want to explore the first path, and to explain why I think it leads to a dead end – or rather to several dead ends, for it turns out that there are several distinct threads bundled together in the intuitive notion of the flow of time, each of which might be held to rescue something of the idea that the passage of time is an objective feature of reality. I want to distinguish these strands, and to argue that they all lead nowhere. I shall say little about the alternative view, that

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the apparent passage of time should be regarded as a psychological phenomenon, but it will be clear that I regard it as much more promising, if only by default. I close with some remarks about avenues that seem worth exploring in the philosophy of time, when we are done with trying to make sense of passage.

1.1 Three paths to passage

What would the world have to be like, for the flow of time to be an objective feature of reality? It seems to me that we can distinguish three possible answers to this question, compatible but largely independent. Hence there are three distinct views, a defence of any one of which would go some way towards vindicating the view that there is something objective about the passage of time. Of course, defending three or two of these claims would be better than defending only one; but one – any one – would rescue something of the intuitive notion:

1. The view that the *present moment* is objectively distinguished.
2. 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*.
3. The view that there is something objectively *dynamic,* flux-like, or "flow-like" about time.

It seems to me that these views 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. I shall say a little more about why they are distinct in what follows. Mostly, however, my plan is to argue against each view independently. In each case, I shall claim, the view in question is not so much false as doubtfully coherent. On examination, it turns out to be hard to make sense of what the view *could be,* at least if it is to be non-trivial, and of use to a friend of objective passage.

2 Is there an objective 'present moment'?

One major component of the intuitive idea of the passage of time is that it involves a distinguished but continually variable 'present moment' – a single 'box' or 'frame', whose contents are continually changing. One version of this idea is at the heart of *presentism,* a view which holds that the present moment is *all there is* – that the past and future simply don't exist. Of course, presentists normally combine this view with the claim that the present moment (or its contents) *change.* But it is worth noting that this is a separate claim. If presentism itself is coherent,

then why not a presentism of a single moment (fictionalist, perhaps, about time and change)? We'll return to this presentism-without-change in a moment.

Presentism is not the only version of the view that there is a distinguished present moment. Another version, more useful for our present purposes, is what has become known as the *moving spotlight view.* As Zimmerman (2008: 213) notes, this image is due to C. D. Broad, who introduces it in this passage:

> We are naturally tempted to regard the history of the world as existing eternally in a certain order of events. Along this, and in a fixed direction, we imagine the characteristic of presentness as moving, somewhat like the spot of light from a policeman's bull's-eye traversing the fronts of the houses in a street. What is illuminated is the present, what has been illuminated is the past, and what has not yet been illuminated is the future. (Broad, 1923: 59)

There is something deeply puzzling about Broad's metaphor, however.[1] After all, place yourself at any moment in time, and ask yourself "Is this moment the *present* moment?" The right answer, obviously, is "Yes" – a fact guaranteed by the stipulation that you are to ask the question *of* a moment, *at* that moment. But this means that if the houses in a street are to play the role of moments of time in Broad's analogy, then the answer to the question, "If you place yourself in one of the houses, and open the front door, will the policeman's bull's-eye be shining in your face?" must also be "Yes" – which means that the light must be shining on all the houses, not just on one!

One might reply that this objection ignores the fact the light shines on each house *in succession,* so that we simply need to add a temporal stipulation to the question about what you see when you open the front door, for all to be well. Will you see the light? Perhaps, but it depends on when you open the door.

But this reply overlooks the fact that the series of houses was supposed to be playing the role of the series of temporal moments. To introduce this temporal aspect to the question, we would need a *second* temporal parameter, other than the one assumed to be represented by the series of houses. Some writers have been prepared to bite this bullet, to try to save the notion of a distinguished (but changing) present moment. But the option is neither appealing nor promising. In the present context, the obvious objection is that the issues of making sense of flow will arise all over again, with respect to the second temporal dimension; and hence that we will have made no progress by introducing it.

The source of the difficulty is that the moving spotlight view is trying to combine two elements, which pull in opposite directions. On the one hand, it wants

[1] As Broad himself appreciates – he does not endorse this view.

to be *exclusive,* saying that one moment is objectively distinguished. On the other hand it wants to be *inclusive,* saying that all moments get their turn – their Warholian instant of fame, when the spotlight turns on them alone. (*Everybody* is a star.)

Imagine an attempt to defend a similar combination in another case: concerning persons, or minds, rather than times. We are familiar with solipsism, which for present purposes we might think of as the view that only our own mind "has the lights on," and that everyone else is a mere zombie. This is an exclusive view, and let us now try to combine it with an inclusive element. Suppose first that "having the lights on" is a matter of being energized by some heavenly bull's-eye – being at the point of focus of the divine gaze, say. And to make the view inclusive, suppose that the focus of the divine gaze varies from person to person. God's eyes follow humanity around the room, as it were. Whoever you happen to be, you'll always find them directed at you. (This is the analogue of the fact that if you place yourself at any moment in time and ask "Is this moment the *present* moment?", the right answer is always "Yes.")

At this point, clearly, we've added inclusivity at the cost of exclusivity. We've lost the idea the one person is objectively distinguished, as *the* object of the divine gaze. We can still make sense of the idea that each person is distinguished *from her own point of view.* But this is too weak to give us what the solipsist wanted: viz., a deep, *non-perspectival* sense in which one person is objectively distinguished. In the temporal case, the same dilemma confronts any attempt to combine an (exclusive) objective "present moment" with the (inclusive) view that all moments get their turn. The inclusive aspect threatens to overwhelm the exclusive aspect, reducing it to an innocuous and uncontroversial perspectivalism.

For a defender of the objective present, the only option at this point seems to be to try to save exclusivity by back-pedalling on inclusivity. The presentist needs to insist that *this* moment, *now,* has privileged status. There is no legitimate inclusive view, except in the sense that we can make sense of it from this exclusive perspective. In place of the inclusive image of a movie, with a long series of frames, the presentist needs to insist that there is only one frame – one aspect of which is labelled *The Story So Far,* being a representation *within this single frame* of what the exclusive view thinks of as the content of the *previous* frames (and similarly for an aspect labelled *Upcoming Episodes*).

But can this shift to the exclusive view succeed, without fatal damage to the intuitions that inclusivity was intended to respect? Here it is worth noting a different between presentism and solipsism. For a solipsist, there may be no need for a surrogate for inclusivity.[2] For a presentist, on the other hand, the desire to make

[2] Unless perhaps for a kind of fictionalism about other persons, to make some sense of one's own behaviour with respect to the zombies with which one shares the planet.

sense of passage creates an immediate and pressing need for such a surrogate. After all, the idea that every instant has its own moment in the spotlight was driven by intuitions about passage. But can we make *enough* sense of this idea, for the purposes of a realist view of passage, within an exclusive view of this kind?

It seems to me that there are two obstacles here, which act together to provide a fatal dilemma for any 'distinguished present' version of objective passage.

1. Frozen-block presentism. The first problem is that in defending exclusivity at the cost of inclusivity, the presentist seems to have thrown out not just the baby, but almost the entire bathroom. After all, what did God need to create, in order to create the whole of reality, as our exclusive presentist describes it? Not a long series of world-stages, but just a single moment, complete with its internal representation of a past and future. It is as if we've built just one house in 'Broad Street', relying on stories its occupants tell about imaginary neighbours as surrogates for all the rest. (They tell us about the time the police shine their bull's eye on the ne'er-do-wells at Number 96, but this is just make-believe. There is no such address, and no family who live there.)

For present purposes, what matters most about this is that we seem to have lost the materials for a realist view of passage, change or temporal transition. All of these notions seem to involve a relation between equals, a passing of the baton between one state of affairs an another. But in this picture, we've lost one party to the transaction. We've lost genuine change, and replaced it, at best, with a kind of fiction about change.

2. Inclusivity strikes back. At this point, our opponent is likely to object that for one reason or another, this conclusion is too strong: the exclusive picture does allow for real transition, change and passage, in so far as it needs to, to make sense of a objectivist view of these things. It allows that change *has happened* and *will happen,* and that's all the objectivist needs.

However, this reply leaves the opponent vulnerable to the second horn of the dilemma. Let's allow that presentist can make sense of future change which is "real enough" for the purposes of a defence of objective passage. Since, by assumption, this act of making sense is being done from a standpoint that privileges the present moment, it is 'inclusive' with respect to all other moments (in whatever sense in can make of such talk at all), in treating them all on a par. The depiction of change in the Upcoming Episodes part of this picture depicts all future moments in the same way. None of them is privileged *in this representation,* though of course each may be depicted as privileged – harmlessly and trivially, as we noted above – from its own point of view. So the distinguished moment view has now become

self-undermining; committed to the view that change can be represented *without* a distinguished moment.

Think of the other houses in Broad Street represented in a picture on the wall of the actual ("present") house. Which, if any, of the other houses should be shown on in the picture as illuminated by the spotlight? If *none,* then the aspect of the model that corresponds to change has disappeared completely. If *one,* then which one – what could break the symmetry? And if *all,* then what has happened to the idea that the representation of change requires a distinguished moment?

To summarise, our strategy was this. Faced with an opponent who holds that change requires a distinguished present moment, we granted her view a distinguished moment from which to speak, and argued that the view then falls victim to a dilemma: either it cannot make sense of change at all, from that distinguished standpoint; or it does so without a distinguished standpoint. Either we lose change, because from this distinguished standpoint there is no change in the past and future; or we accept that change can be modelled in an *inclusive* way (i.e., without a distinguished moment), which undermines the motivation for playing the game in this way in the first place.

2.1 Comparison with McTaggart

As readers may have noticed, there are similarities between the above discussion and J. M. E. McTaggart's famous (1908) argument for the view that time itself is unreal. McTaggart's argument proceeds in three steps:

1. He argues that there is no time without change.

2. He maintains that real change requires that events change with respect to the properties of *pastness, presentness* and *futurity:* they begin as *future,* and become *present,* and then *past.* Combined with premise (1), this implies that the reality of time depends on the reality of the properties of pastness, presentness and futurity.

3. He argues that these properties cannot be real for they are incoherent: each event must have all three, and yet they are contradictory.

Many commentators get off the boat at steps (1) or (2), denying that time requires change, or denying that change needs to be conceived in terms of acquisition and loss of the properties of pastness, presentness and futurity. But these options hardly reduces the interest of the argument as whole; which can be thought of, after all, as an argument for the need to jump ship in one or both of these ways, if one wants to be a realist about time and/or change.

Much interest therefore lies in step (3) – especially so, in the present context, since it is easy to reconstrue McTaggart's argument as an argument against the moving spotlight view, using the two properties *illuminated* (i.e., present) and *not illuminated* (not present) in place of the three properties past, present and future.

At this point, in this slightly modified form, McTaggart's argument claims that each moment must have both properties, *illuminated* and *not illuminated;* and that this is incoherent. My approach has been to take a slightly different tack, emphasising the pressure on the moving present view to combine an *inclusive* view, in which all moments are on a par with respect to these properties, with an *exclusive* view, in which one moment is distinguished as uniquely illuminated. We saw that the inclusive element threatens to drive out the exclusive element, by requiring us to acknowledge that each moment is equally illuminated, from its own point of view.

I have noted the option of stressing the exclusive view, by insisting that we can speak from nowhere *except* a particular moment, and hence that we can say truthfully that only *that* moment is illuminated. This option is available to opponents of McTaggart's step (3), too. They can simply deny that all events have all three properties, pastness, presentness and futurity, insisting from the standpoint of a particular moment (while denying the availability of any other standpoint) that each event only has one: if it is not present, then it is either past or future (though not both). But for McTaggart's opponents, as for mine, this option leads to a fatal dilemma. Either it discards the baby with the bathwater, leaving them with a frozen presentism, lacking the conceptual resources to make sense of change (by their own lights). Or it sneaks the inclusive view back in, in its own depiction of past and future change.

I conclude that there is no coherent notion of an objectively distinguished present, at least of the sort required to provide an ingredient of an objective flow of time. If objective flow is to be a coherent notion, it will have to constituted, somehow, from the remaining ingedients.

3 An objective direction of time?

The second ingredient is the idea that time has an objective *direction* – that there is an objective distinction between past and future, earlier and later. Concerning this ingredient, we can get a good sense of what is at issue by comparing some remarks from writers on opposite sides. First, on the "pro" side of the question, consider the following characterisation of the passage of time by Tim Maudlin:

> The passage of time is an intrinsic asymmetry in the temporal structure of the world, an asymmetry that has no spatial counterpart. It is the asymmetry that grounds the distinction between sequences which run from past to future and sequences which run from future to past. Consider, for example, the sequence of events that makes up an asteroid traveling from the vicinity of Mars to the vicinity of the Earth, as opposed to the sequence that makes up an asteroid moving from the vicinity of Earth to that of Mars. These sequences might be "matched", in the sense that to every event in the one there corresponds an event in the other which has the same bodies in the same spatial arrangement. The topological structure of the matched states would also be matched: if state B is between states A and C in one sequence, then the corresponding state B* would be between A* and C* in the other. Still, going from Mars to Earth is not the same as going from Mars to Earth. The difference, if you will, is how these sequences of states are oriented with respect to the passage of time. If the asteroid gets closer to Earth as time passes, then the asteroid is going in one direction, if it gets farther it is going in the other direction. So the passage of time provides an innate asymmetry to temporal structure. (2007: 108)

As Maudlin points out, however, not just any intrinsic asymmetry will do the trick:

> [T]he passage of time connotes more than just an intrinsic asymmetry: not just any asymmetry would produce passing. Space, for example, could contain some sort of intrinsic asymmetry, but that alone would not justify the claim that there is a "passage of space" or that space passes. (2007: 109)

So one question we want to keep in mind, in considering the general issue of intrinsic temporal asymmetry and directionality, is whether a particular asymmetry is of the right kind to "produce passing", and what kind this could be.

3.1 Boltzmann's Copernican moment

The possibility that there may be no objective direction of time is famously presented in the following remarks by Ludwig Boltzmann, from his *Lectures in Gas Theory* of 1896–1898:[3]

[3]Boltzmann first presents these ideas in an (1895) letter to *Nature,* attributing them to his 'old assistant, Dr Schuetz.' His suggestion about the non-objectivity of the direction of time is offered in

> One can think of the world as a mechanical system of an enormously large number of constituents, and of an immensely long period of time, so that the dimensions of that part containing our own "fixed stars" are minute compared to the extension of the universe; and times that we call eons are likewise minute compared to such a period. Then in the universe, which is in thermal equilibrium throughout and therefore dead, there will occur here and there relatively small regions of the same size as our galaxy (we call them single worlds) which, during the relatively short time of eons, fluctuate noticably from thermal equilibrium, and indeed the state probability in such cases will be equally likely to increase or decrease. For the universe, the two directions of time are indistinguishable, just as in space there is no up and down. However, just as at a particular place on the earth's surface we call "down" the direction toward the center of the earth, so will a living being in a particular time interval of such a single world distinguish the direction of time toward the less probable state from the opposite direction (the former toward the past, the latter toward the future). (1964: 446–447)

Let us compare Boltzmann's viewpoint with Maudlin's. Would Boltzmann deny that there is a difference between asteroid moving from the vicinity of Earth to that of Mars and the same asteroid moving from the vicinity of Mars to that of Earth? I think we can be sure that he would not! Rather, he would maintain that while of course the two cases are *different,* there's no fact of the matter as to which is which. At best, there's a fact of the matter relative to a particular temporal perspective, or choice of coordinate frame. A good analogy is with the issue as to whether, in a Newtonian framework, there is an objective distinction between an asteroid at rest and an asteroid moving at a uniform non-zero velocity. Boltzmann's view compares to the relationist view that there is no such distinction: fix a coordinate frame, and you can certainly distinguish between the two cases, but nothing distinguishes a unique "correct" coordinate frame.[4]

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the context of an avowedly tentative proposal concerning the origins of the state of thermodynamic disequilibrium in which we now find ourselves. Despite certain striking theoretical advantages – in particular, that it permits the observed thermodynamic time-asymmetry to emerge from a model with no temporal asymmetry at all, at the global level – this proposal about the source of disequilibrium faces seemingly damning objections (see, e.g., Price 2004, for more on these issues). But neither these difficulties, nor the tentative spirit in which Boltzmann presents the proposal, in any way diminish the importance of the recognition that the direction of time might not be objective. In putting that possibility on the table, Boltzmann is, as Hans Reichenbach (1956: 128) puts it, providing "one of the keenest insights into the problem of time."

[4]Another analogy, to which we'll return, is a reworking of a famous example we have from Kant (opposing Kant's own view about the case) : a world with two hands of opposite parity, but no fact

For present purposes, the important issue is this one. If Boltzmann is wrong, what exactly is he wrong *about?* What *extra* feature does the world have, that it does not have in the Boltzmann picture? What could make it the case that there is an objective earlier–later relation?

3.2 Orientability: necessary but not sufficient

Our interest in the issue of the direction of time is guided by an attempt to make sense of the notion of the passage or flow of time. If time has a direction in a sense relevant to passage, then presumably it is the same everywhere – passage is supposed to be global, universal and unidirectional. This implies that a precondition of any relevant notion of the direction of time is that it be possible to *assign* a temporal direction at every place and time, in a consistent way. In other words, we want to be able to pick a temporal direction, and label it (say) the positive direction, without our labels suddenly changing, as we move from place to place.

Formalised a little bit, this means that a precondition for the existence of any relevant notion of the direction of time is that the spacetime within which we live be temporally "orientable", in the following sense:

> A relativistic spacetime (M, g_{ab}) is *temporally orientable* iff there exists a continuous everywhere defined timelike vector field on M. If such a field exists, reversing the arrows gives another such field. The choice of one of these fields as "pointing the way to the future" is what is meant by the assignment of a time orientation. (Earman and Wüthrich, 2008, fn. 7)

The important point to note here is that such an "assignment" of a time orientation, while it requires temporal orientability, does not require or imply that there be a unique *correct* assignment, dictated by some objective feature of reality. So, while orientability is necessary for the existence of an objective direction of time, in the intended sense, it is far from sufficient. Orientability ensures that if we decide by convention that one of two asteroids is travelling *from* Mars, *towards* the Earth, then we can extend the convention to the rest of spacetime in a consistent way. It does not ensure that such a choice of convention would be objectively *right* or *wrong,* or even tell us what it would *be* for there to be an objective standard of such a kind.

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of the matter as to which of the two is the left hand and which the right hand.

3.3 Earman *v.* Reichenbach

We stressed a moment ago that if there is a direction of time of a kind relevant to the passage of time, it had better be a *global* notion. This point connects closely with an argument John Earman offers against Reichenbach, in a seminal (1974) paper. Reichenbach's posthumous book, *The Direction of Time* (1956), defends a view resembling Boltzmann's, to the effect that the direction of time is potentially a local matter, reducible to the direction of entropy increase in a particular region of spacetime.[5] Earman objects as follows:

> Reichenbach himself grants that space-time can be assumed to be a manifold with a null cone structure, and can be assumed to be temporally orientable. But this seems enough to justify the following Principle of Precedence.
>
> PP Assuming that space-time is temporally orientable, continuous timelike transport takes precedence over any method (based on entropy or the like) of fixing time direction; that is, if the time senses fixed by a given method in two regions of space-time (on whatever interpretation of 'region' you like) disagree when compared by means of transport which is continuous and which keeps timelike vectors timelike, then if one sense is right, the other is wrong.
>
> To put the matter in a nutshell, PP says that (assuming temporal orientability) once the time sense is established anywhere in space-time, the structure of space-time (in particular, the null cone structure and spatio-temporal continuity) serve to fix it everywhere. From PP we can conclude that if there is disagreement, then either (i) neither time sense is right or wrong or else (ii) one is right and the other is wrong, and, therefore, the given method is not generally correct. Using the following fact
>
> F With Reichenbach's entropy method it is always physically possible and in many cases highly likely (according to statistical mechanics) that there will be disagreement.
>
> we can conclude that it is always physically possible and in many cases highly likely that either (a) there is no right or wrong about time

[5] As I noted above, Reichenbach describes Boltzmann's view on this point as one of the "keenest insights" about time, saying that Boltzmann was the "first to have the courage to draw this conclusion." (1956: 128)

> direction-talk about which direction is "really" the future and which is "really" the past is not meaningful anywhere in space-time or (b) the entropy method yields the wrong result somewhere in space-time. Reichenbach can accept neither (a) nor (b) because he claims that the content of the philosophically purified concept of time direction is given by the entropy method. (1974: 22)

However, so long as we recognise that there are two distinct conceptions of the project of giving an account of the direction of time – roughly, Maudlin's, which treats the direction of time as something global and fundamental, and Boltzmann's, which treats it on a par with "up" and "down" – then it is easy to see how Reichenbach might have responded to Earman. He could say that if by "direction of time" we agree to mean Boltzmann's local notion, then he rejects PP; while if we mean Maudlin's global notion, then he can accept Earman's option (a). The trick is simply to notice that a "philosophically purified concept of time direction" requires that we distinguish two notions: about one of them, there may be "no right or wrong"; about the other, the truth may vary from place to place.[6]

I am not sure to what extent this irenic distinction would have appealed to Earman's targets – the proponents of the view that "the" direction of time was reducible to the thermodynamic asymmetry. But for present purposes, since our interest is in the prospects of making sense of a strong, global sense of the direction of time, we can ignore this interpretational issue: Earman seems right that direction in the strong sense cannot be reduced in this way, whether or not Reichenbach and others actually thought that it could be.

3.4 Earman's Heresy

Earman took the view that the existence of an objective direction of time turns on issues of time-invariance and reversibility to be so much an orthodoxy that he refers to the alternative as a heresy. As he puts it:

> [I]t will be useful for sake of contrast to state explicitly a view which goes directly counter to the reductionist position outlined above. I will refer to this view as *The Time Direction Heresy.* It states first of all that **if it exists,** a temporal orientation is an intrinsic feature of space-time which does not need to be and cannot be reduced to nontemporal features, and secondly that the existence of a temporal orientation does not hinge as crucially on irreversibility as the reductionist would

[6] True, it might be argued that the latter is not properly called a notion of the direction *of time;* but at this point the argument is about terminology.

> have us believe. I am not at all sure that The Time Direction Heresy is correct, but I am certain that a failure to consider it, if only for purposes of contrast, will only lead to further stagnation. (1974: 20, emphasis in bold mine)

As Maudlin (2007: 108) notes, "Earman himself does not unequivocally endorse the Heresy, but does argue that no convincing arguments against it could be found, at that time, in the very extensive literature on the direction of time." "Over three decades later," Maudlin continues, "I think this is still the case, and I want to positively promote the Heresy. ... [My] Chapter can be seen as a somewhat more aggressive companion piece to [Earman's]."

Like Maudlin, I am a fan of Earman's Heresy; and I, too, want to support it in blunter form. But unlike Maudlin, I do so by denying its antecedent – i.e., by denying that there is any direction of time in the strong sense – not by affirming that there is such a direction (though not one reducible to irreversibility). I think that Earman is right to reject reductionism, and to question the relevance of the issue of time-invariance of the laws of physics to that of the direction of time; but wrong to the extent that he believes that the answer might lie somewhere else. On the contrary, I claim: the right answer is that there is no answer.

3.5 Earman and the no direction option

The possibility that there might be no objective direction of time is explicitly on Earman's radar, early in his paper. We have seen that he acknowledges it in the passage quoted above, in which he introduces his Heresy. And a page before that, he sets out some of the issues to be considered, as follows:

> P4 Does the world come equipped with a time orientation?
>
> P5 If the answer to P4 is affirmative, where does it come from? If the answer is negative, what explains our psychological feeling of a direction for time?
>
> P6 If the answer to P4 is affirmative, how do we know which of the two possible orientations is the actual one?
>
> P4 and P5 are in rather crude form. One of the purposes of this paper is to sharpen them. If there is a global time order, then P6 amounts to the following: given that either *E(x, y)* or *E(y, x)* [i.e., *x* is earlier than *y,* or *y* is earlier than *x*], how do we know which holds? (1974: 19)

However, I think it is fair to say that with one (partial) exception, these questions hardly get addressed in Earman's paper. The main exception is the first part

of P5, but even this is addressed only in a conditional and negative fashion. In defending the Heresy, Earman defends the view that *if* there is a temporal orientation, then it is not reducible to issues of irreversibility and the like. But this is not to argue that there *is* such an orientation; or to explain where it comes from, if so; or to answer P6.

By the end of Earman's paper, however, the possibility of a negative answer to P4 seems to have dropped out of sight:

> In summary, I think that there are grounds for believing that entropy is not as important as some philosophers would have us believe for the temporal asymmetries discussed above. It also seems to me that these asymmetries are not crucial for some of the aspects of the problem of the direction of time; for on my view, laws and/or boundary conditions might have been such that these asymmetries did not exist and *still it would have made sense to speak of a direction for time,* or else the laws and boundary conditions might have been such that these asymmetries were the reverse of what they are now without it necessarily being the case that *the direction of time is the reverse of what it is now.* (1974: 45, my emphasis)

But nowhere does Earman venture an opinion about what it would be for the direction of time to be "the reverse of what it is now" – or, what would presumably amount to the same thing, what it is for time to *have* a particular direction.

3.6 Great heroics

Earman does consider the opposing view, that there is no direction of time, and to some extent his conception of what it is for there to be a direction of time can be discerned from what he says against the opposing view. But the inference is difficult, because Earman takes his main opponent – the Reichenbach–Gold view, as he calls it – to be arguing that the existence of a direction of time depends on the non-time-invariance of the laws of physics. Against this opponent, he argues (forcefully, in my view) that the considerations which might lead us to deny the existence of a direction of time in the case of a time-invariant physics would apply equally forcefully in the non-time-invariant case. This is a good argument against the Reichenbach–Gold view, but it helps rather than hinders the more radical view that there is no direction of time (whatever the time-invariance properties of the laws of physics). In focussing his attention on the Reichenbach–Gold view, Earman seems to leave his flank open to a Boltzmannian opponent.

Earman introduces his discussion of the Reichenbach–Gold view with these words:

> The radical view that if all the laws of nature were time reversal invariant, then there would be no right or wrong in the matter since there could be no temporal orientation, is a view which can also be discussed in Reichenbach's writings. Since this view need not be based on a reductionistic attitude towards space-time, since it has been held by many others besides Reichenbach, and since it goes to the heart of the obsession with irreversibility, it will be examined in some detail in the following section. (1974: 23)

Earman describes the Reichenbach–Gold view itself as follows:

> Now imagine that T is a super theory which captures all of the laws of physics and suppose that T is time reversal invariant. In such a case, Reichenbach would maintain that for any $m \epsilon \mathfrak{M}_{T^D}$, m and $\mathbf{T}(m)$ are not descriptions of two different physically possible worlds but rather are "equivalent descriptions" of one and the same world and that, therefore, "it would be meaningless to ask which of the two descriptions is true" [Reichenbach, 1956: 31–32]. Reichenbach is not alone in this interpretation. For instance, T. Gold says that in the envisioned situation, $\mathbf{T}(m)$
>
> > is not describing another universe, or how it might be but isn't, but is describing the very same thing [as m]. [Gold, 1966: 327]
>
> The upshot is supposed to be that if universal time reversal invariance holds, there is no objective fact of the matter as regards time direction or time order since m and $\mathbf{T}(m)$ involve different time directions and orders. (Earman, 1974: 23)

Most of Earman's objections to the Reichenbach–Gold view are of the kind mentioned above, turning on the claim that there is a direction of time in the non-time-invariant case. The first, however, is more general:

> Even before going into the details of time reversal invariance, I think the implausibility of the Reichenbach–Gold position should be apparent from several considerations. First, a characterization of invariance under charge conjugation **C** and mirror image reflection **P** can be given along the same lines as given above for **T** invariance. If then the Reichenbach–Gold position is correct for **T**, why isn't it also correct for **C** and **P**? Why doesn't **C** (**P**) invariance imply that m and $\mathbf{C}(m)$ ($\mathbf{P}(m)$) are not descriptions of two different possible worlds but rather

> equivalent descriptions of the same world? And would it not then follow that the predicates 'having a positive (negative) charge' and 'having a righthanded (lefthanded) orientation' do not correspond to any objective feature of reality? (If the conditions of the **CPT** theorem of quantum field theory apply, then m and **CPT**(m) will always be equivalent descriptions.) Either this consequence must be swallowed or else it must be maintained that there is some feature which makes m and **T**(m) but not m and **C**(m) or m and **P**(m) equivalent descriptions. To grasp the second horn of this dilemma would require an explanation of what the relevant feature is. No such explanation seems forthcoming. Grasping the [first] horn would seem to involve a great heroism [Earman notes here that Gold (1967: 229) does grasp this horn]; but *in any case it would be an admission that there is nothing special about time direction per se and that the alleged nonobjectivity is the result of a far flung nonobjectivity.* (1974: 24)

I'll return in a moment to the option Earman takes to "involve a great heroism", which seems to me the right choice here; although now to require no great courage, if it ever did.[7] Earman seems quite right to suggest that the case of **T**, **C** and **P** are likely to be on a par. He returns to the point a little further on in his paper, in connection with the claims of another proponent of the Reichenbach–Gold view, Max Black.

Asking what argument could be given in favour of the Reichenbach–Gold position, Earman (1974: 26) offers the following suggestion:

> One obvious suggestion would be to try to accommodate time reversal to the passive interpretation of symmetry. For on the passive interpretation, a symmetry operation corresponds not to a change from one physical system to another but rather a change, so to speak, of the point of view from which the system is described; if both the original description resulting from the original point of view and the new description resulting from the new point of view are equally legitimate according to T, then T is said to be invariant under the transformation which goes from one point of view to the other. Not surprisingly, such an interpretation of time reversal invariance has been offered. Max Black concludes that if all the laws of physics were time reversal invariant, the relation of chronological precedence would be an "incomplete" relation in that it would really be a three-place relation like the relations of being to the left of and being to the right of.

[7] From my perspective, the true hero of the contemporary scene is Maudlin, playing a stout Cardinal Bellarmine to Boltzmann's Galileo.

> We would have to say that the very same series of events *A, B, C,* might properly be described by one observer as being in temporal arrangement in which *A* occurred first, while that very same series could properly be described by some other observer as being in the opposite temporal arrangement in which *C* occured first. [Black, 1962: 192]

To this, Earman responds:

> Black seems correct to the extent that his conclusion would follow if the passive interpretation of **T** were legitimate. But many physicists regard this and similar conclusions about **C** and **P** as a *reductio ad absurdum* of the passive interpretation of the discrete symmetries **C**, **P**, and **T**. The passive interpretation of continuous symmetries, like spatial rotation, is meaningful since one can suppose at least in principle that an idealized observer can rotate himself in space in correspondence with the given spatial rotation. ... But how is an observer, even an idealized one, supposed to "rotate himself in time ?" (1974: 26–27)

Again, I think Earman is quite correct to treat **C**, **P**, and **T** as on a par here. But the challenge that follows seems unsuccessful. The obvious reply is that the passive interpretation of the symmetries requires not the rotation of the original idealized observer, but only (at most), the idealized postulation of a second observer who stands in the appropriate "rotated" relationship to the first observer. Far from being unimaginable in the temporal case, this is exactly the possibility that Boltzmann imagines – and for real observers, too, not merely idealized ones. (The view Black is describing here is essentially Boltzmann's, of course.)

Earman continues his response to Max Black by pointing out that an appeal to the passive interpretation of the symmetries is much more powerful than Black himself takes it to be:

> *Black's passive interpretation of time reversal is too powerful; for this conclusion follows whether or not the laws of physics are time reversal invariant.* Thus, it follows from the very fact that a passive interpretation of spatial rotation can be given that the relations of being to the left of and being to the right of are "incomplete relations" irrespective of whether or not the laws of physics are invariant under spatial rotations. Similarly, the "incompleteness" of the relation of temporal precedence would follow from the existence of a passive interpretation of time reversal irrespective of whether or not the laws of physics are time reversal invariant. (1974: 27)

"As a result," Earman concludes, "the passive interpretation is of no use to someone who wants to maintain the Reichenbach–Gold position." (1974: 27)

Once again, I think that Earman's objection here is entirely correct, as a point against the Reichenbach–Gold–Black view (at least to the extent that these authors really are committed to the claim that if physics is not time-invariant, then there is a *fundamental* direction of time). But it is no objection at all against what I am treating as the Boltzmann view, viz., that there is no fundamental direction of time in any case, whether or not the laws are time-invariant. (Again, Earman has his eye on the Reichenbach–Gold position, and doesn't watch the threat from the other flank.)

3.7 Modal collapse?

Another concern that Earman mentions about the "passive" interpretation of the **C**, **P** and **T** symmetries is, if I understand it correctly, that it sets us on (or threatens to set us on) a slippery slope towards treating *all* differences as "merely notational."

> [I]f on the Reichenbach-Gold position, all possible worlds are not to collapse into a single one, there must be some objective feature which separates them and which can be ascertained to hold independently of the direction of time. (1974: 24)

In other words (as I interpret the point), it would clearly be *reductio* of the "passive" methodology if it required us to treat all differences between theories as mere differences in notation, describing the same possible world. To prevent a slide to this absurdity, we need some fixed points – roughly, some features which can be identified independently of alternative theoretical notations on offer. In the temporal case, these need to be features, as Earman says, "which can be ascertained to hold independently of the direction of time."

There are some interesting and deep issues here, which deserves much more attention than I can give them in this context. For present purposes, I simply want to point out that there's a danger in the other direction, too. If the desire for fixed points makes us *too* unadventurous, we'll decline some of the greatest adventures that science has to offer – those magnificent Copernican moments, when what we had always assumed to be part of the structure of reality is revealed as an artifact of our parochial viewpoint. This is what Boltzmann proposes about the direction of time, and it isn't a good objection to a well-motivated suggestion of this kind – i.e., in particular, a suggestion motivated by our developing sense of the world's basic symmetries – to point out that if we were to follow the same path all the way to the horizon, we would end up as *über*-Kantian idealists, attributing *all* structure to our own viewpoint. After all, there be monsters at the other end

of the slope, too – Solipsism and Ignorance, to name but two. So we need to stick out our necks to some extent, and the safest policy seems to be to follow the recommendations of physics, in so far as we can understand what they are. The question is, has Boltzmann got them right, in the case of the direction of time?

3.8 Counting worlds

We have been considering such arguments as may be found in Earman's (1974) paper for answering "No" to his own question:

P4 Does the world come equipped with a time orientation?

There's a prior question, which Earman does not formulate explicitly. Let's call it:

P0 What would it *be* for the world to "come equipped with a time orientation" (in the sense required by a positive answer to P4)?

The answer to P0 implicit in Earman's paper is in terms of the distinctness of worlds. It is the denial of the view he attributes to Reichenbach and Gold:

> [F]or any $m \in \mathfrak{M}_{T^D}$, m and $\mathbf{T}(m)$ are not descriptions of two different physically possible worlds but rather are "equivalent descriptions" of one and the same world .... (1974: 23)

In other words, Earman's answer to P0 seems to be that for the world described by theory T to come equipped with a time orientation is for m and $\mathbf{T}(m)$ to describe different possible worlds.

At first sight, the most helpful part of this suggestion seems to be the idea that a temporal orientation doubles the number of possible worlds. After all, there's going to be an obvious move of claiming that both m and $\mathbf{T}(m)$ can be construed as description of *either one* of the pair of worlds concerned, under an appropriate transformation of "description".[8] The bulwark against the Reichenbach–Gold view is the seemingly objective fact about the number of worlds.

Or is it? *Mere* world counting can't do the trick, presumably. Any additional binary property of world-histories will multiply possible worlds in this way, whether it is temporal or not. World counting alone takes us no closer to an understanding of what it is for two worlds to differ specifically with respect to the direction of time. By analogy, the question of objective parity isn't settled by the issue of what choices God faces when he creates a one-hand world, unless we have already singled-out parity from other properties that might distinguish two hands.

[8] The move is a baby case of Putnam's model-theoretic argument, and, in virtue of the symmetries, especially hard to resist.

(The distinction between red hands and green hands will double God's choices, too, but objective colour has nothing to do with objective parity.)

At this point, I find it very difficult to see, in the abstract, how *anything* could count as a satisfactory answer to Po. Accordingly – conscious of the dialectical deficiencies of stares, whether incredulous, puzzled or merely blank! – I want to try to bring the issue down to earth. I want to return to questions about possible lines of inference from observed temporal asymmetries to *knowledge* of temporal orientation; in the hope that this will clarify the issue of the *content* of such knowledge, as well as the problems or opportunities for its acquisition.

3.9 Three grades of temporal asymmetry

Suppose everything in the universe were to vanish, except a single giant signpost, pointing forlornly to a particular corner of the sky. Or suppose that a universe had always been like this. This spatial asymmetry would not require that *space itself* be anisotropic, presumably, or that the direction in question be distinguished by anything other than the fact that it happened to be the orientation of signpost. Similarly in the case of time. The contents of time – i.e., the arrangement of physical stuff – might be temporally asymmetric, without time itself having any asymmetry. Accordingly, we need to be cautious in making inferences from observed temporal asymmetries to the anisotropy of time itself.

This caution-requiring step precedes another, if our interest is the direction of time in Earman's and Maudlin's sense. As we noted earlier, temporal anisotropy is necessary but certainly not sufficient for a direction of time: not all possible anisotropies have the right character to constitute the direction of time. Imagine some simple cases: suppose time is finite in one direction, infinite in the other; or more granular in one direction than the other (in the sense that the gaps in discrete time get progressively smaller). In both cases, it would seem reasonable to say that time itself was anisotropic. But what relevance would factors like this have for the existence or orientation of an objective distinction between earlier and later, or for "passage"? Why shouldn't it remain an open question whether the asymmetrically bounded universe had an objective temporal direction at all; and if so, whether the bounded end was really the past or the future?

In order to exercise due caution at both steps, a defender of the objective direction of time thus needs to answers to questions such as these:

1. Is time anisotropic *at all,* and how could we tell? What could constitute good grounds for taking it to be so, and do we have such grounds?

2. What kind of temporal anisotropy would be the right kind, from the point of view of grounding temporal passage? And what kind of grounds do we

have for thinking that time is anisotropic *in this sense?*

Can these questions lead us to an answer to P0?

3.9.1 The epistemology of anisotropy

Taking the easier question first, what would count as evidence of anisotropy? Some writers take the view that time-asymmetry in the physical laws would be evidence of anisotropy.[9] For example, Paul Horwich argues that in this case the anisotropy of time would be an hypothesis with explanatory force:

> Once a genuine instance of nomological irreversibility has been identified, it is not hard to justify the inference that time is anistropic. Suppose there is a physically possible process ABCD whose temporal inverse is impossible. Let (ABCD) designate the process whose temporal orientation is unspecified—merely that B occurs between A and C, and C between B and D. Then a physically necessary condition for the occurrence of (ABCD) is that A is earlier than B. Thus the relation *earlier than* enters into explanations that are fundamental, for we have no deeper account of that necessary condition. In particular, we cannot suppose that the possibility of (ABCD) will be found to depend on its orientation relative to certain other events: for in that case the reverse of ABCD would not be physically impossible. (1987: 53)

However, I think this argument overlooks the fact that there will always be a "Machian" reading of the kind of lawlike irreversibility that Horwich has in mind here – simply a law to the effect that all instances of the kind (ABCD) have the same temporal orientation. The Machian law will do the same job of explaining the orientation of any particular (ABCD): the opposite orientation would not match all the other instances. True, it won't explain why it isn't the case that all instances have the opposite orientation. But even if we grant for the moment that this is a distinct possibility, rather than a notational variant (more on this issue below), Horwich's version of the explanation shares an exactly analogous deficit: in his case, there is nothing to explain we don't find the reverse law, with respect to the temporal anisotropy in question. (Why shouldn't it be *later* rather than *earlier* that does the explanatory job, as it were?)[10]

In the present context, the main relevance of this point is that it suggests that proponents of the view that time has an intrinsic direction are even further away

[9] Indeed, Horwich (1987: 54) seems to conclude that this is both necessary and sufficient for anisotropy.

[10] Cf. Pooley (2003) for a convincing presentation of this kind of argument.

from their goal than might be supposed. Anisotropy isn't sufficient for their case, but it is necessary; and they frequently take heart from the one apparent case of a fundamental lawlike time-asymmetry in contemporary physics, the so-called **T** violation.[11] Thus Maudlin, for example:[12]

> The discovery that physical processes are not, in *any* sense, indifferent to the direction of time is important and well known: it is the discovery of the violation of so-called CP invariance, as observed in the decay of the neutral K meson. ... [V]iolation of CP implies a violation of T. In short, the fundamental laws of physics, as we have them, *do* require a temporal orientation on the space-time manifold. (2002: 267)

One way to read this passage – not, as we'll see, the reading that Maudlin intends – would be to interpret "require a temporal orientation on the space-time manifold" as meaning "require that space-time be temporally orient*able.*" In that case, the conclusion seems correct. What would it mean to say the laws exhibited a specific temporal asymmetry, unless one could orient a choice of temporal coordinate consistently across space-time, in the manner guaranteed by orientability?

This isn't what Maudlin has in mind, however. Orientability is a much weaker condition than existence of an objective distinction between earlier and later – it doesn't imply even that time is *anisotropic,* much less that it is *objectively directed.* Where Maudlin makes the above remarks, he himself has just distinguished orientability from the existence of a temporal orientation, noting that in the relativistic models with which he is concerned, the former is provided by the light-cone structure: they are "space-times in which the light-cones are divided into two classes, such that any continuous timelike vector field contains only vectors which lie in one of the classes." (2002: 266)

Maudlin then notes what we need to add to such a model, to provide an *orientation,* or distinguished direction:

> [What] we need to do is to identify one of these classes as the *future* light-cones and the other as the *past* light-cones. Once I know which set is which, I can easily distinguish a Mars-to-Earth asteroid from an Earth-to-Mars one. (2002: 266)

[11] It is controversial whether this should be counted a case of time-asymmetry at all. Arntzenius and Greaves (2007) argue that what it reveals is simply that time-reversal requires CP reversal, as well as T reversal. Under that construal, there is no fundamental irreversibility. But I put that aside.

[12] In the light of Maudlin's blunt endorsement of Earman's Heresy, it is a little surprising to find him in this camp, taking issues of T invariance to be relevant, one way or the other, to the existence of an objective orientation of time. However, the passage provides a convenient statement of a common view.

In the passage quoted previously, then, we should read Maudlin as claiming that the T-violation exhibited by the neutral kaon "requires" such an orientation. But as our objection to Horwich's argument makes clear, however, this is simply not true: a lawlike time asymmetry does not even require temporal anisotropy, let alone the true directionality that Maudlin is after.[13] It is true, of course, that the T-asymmetry of the neutral kaon could provide the basis of a universal convention for *labelling* lightcones as "past" and "future". But this no more requires that time even be anisotropic – let alone objectively oriented – than does our universal signpost for space, in the example above.

3.9.2 An arrow that couldn't point backwards?

Suppose for the moment that Horwich, Maudlin and others were right, and that a lawlike T-violation such as that of the neutral kaon did require, or at least provide evidence for, a temporal anisotropy. As we have stressed, such an anisotropy would not necessarily provide an objective direction. It would explain neither what *constitutes* the objective distinction between past and future, if there is such a thing; nor how we could *know* which direction was which. By the lights of a proponent of the view that time has an intrinsic direction, after all, it would still seem to be an *open question* whether this nomologically-characterised arrow really points towards the past or the future. (Couldn't God have made the world with the reverse asymmetry, with respect to the objective earlier–later distinction?)

This challenge gives us a handle on our second question above – on the issue of what kind of temporal anisotropy would be the right kind, for a defender of the view that time has an objective direction. It has to be an asymmetry which comes with an answer to the open question objection. This challenge functions much like open question arguments elsewhere in philosophy. It objects to any proposed reduction-base for the fundamental asymmetry that it cannot be what we were after, because, in making sense of the issue of its own temporal orientation, we defeat the proposed identification.

To meet this objection, any proposed fundamental asymmetry needs to "connect" with something already in play – with something that can be argued to be *constitutive* of the distinction between past and future, apparently, since only this will defeat the open question. There seem to be three candidates: the special (low-entropy) *initial conditions* of the universe, *causation,* and *conscious experience.*

[13] By way of analogy, consider again a modified Kantian example: a universe comprising many hands, in which it is a matter of law that all the hands are congruent. The laws of this world certainly exhibit a strong P violation, but the law as formulated compares hands only to other hands, not to space itself; and requires no fact of the matter about whether they are "really" left hands or right hands. So, despite the lawlike P violation, space itself need not be handed – let alone objectively handed in one sense rather than the other.

3.9.3 Initial conditions

The case for including initial conditions on this list rests on the argument that the familiar temporal asymmetries of our experience – including the asymmetry of our own memories – turn out to depend on the fact that the universe was in a state of very low entropy, some time in the distant past. Leaving the details entirely to one side, the crucial point, for present purposes, is the suggestion that it is not accidental that the low entropy boundary lies in the *past.* If 'past' means, *inter alia,* something like *the direction in which we remember things,* then it is not an open question why the low entropy boundary condition lies in the past but not the future.

That's the good news. The bad news comes in three parts:

1. First, and perhaps most obviously, there's the issue put on the table by Boltzmann. What if the required "initial" conditions are not found uniquely at one temporal extremity of the universe, but can occur in multiple locations, in either temporal direction from our own era?

2. Second, even if we could assume that the required conditions were unique, it is far from clear that a low entropy initial condition need constitute an anisotropy *of time* at all. On the contrary, it is usually presented as a temporal asymmetry in the physical arrangement of matter *within* space and time – and in the classical case it is hard to see how else one could present it.

3. Third, the point of Boltzmann's speculation – which is the origin of this proposal to tie low entropy boundary conditions with the intuitive idea of the past – is that it leads to a picture in which the direction of time is not fundamental. At best, it is something we have 'locally', in appropriate proximity to non-equilibrium regions. With Boltzmann's picture in play, what reason do we have to think that the direction of time is anything more fundamental, even if the low-entropy boundary condition were unique? If Boltzmann's picture could 'explain the appearances' in the non-unique case, why is something more fundamental needed to do so in the unique case?[14]

In answer to the second point, it might be pointed out that general relativity introduces other possibilities. Roger Penrose (1989, chs. 7–8), for example, proposes that the low entropy boundary condition is a product of a lawlike time-asymmetric constraint on spacetime, namely, that its Weyl curvature be zero (or at least finite) at initial singularities. Here, the source of the low entropy past

[14]Maudlin himself wants to challenge the claim that Boltzmann's hypothesis could explain the appearances, in the non-unique case. We'll come to those objections in a moment.

seems explicitly represented as a feature of spacetime – and in a way which makes it unique, apparently, thus offering a solution to the uniqueness problem, too.

Perhaps the simplest way to see how little this helps with the main problem is to ask what difference it would make if we considered a time-symmetric version of Penrose's proposal, with a lawlike low entropy constraint at both ends of a recollapsing universe (or the middle of a bouncing universe, or simply Boltzmann fluctuations). In that case, for Boltzmann-like reasons, we want to say that there is no global direction of time, but only local 'explanations of the appearances'. But such an addition takes away nothing from the model in the regions in which it coincides with the original model, apparently – there's no objective direction of time which we have to *remove* from the model, in order to make it symmetric. So there's nothing over and above 'explanation of the appearances' in the original case, either.[15]

3.9.4 A causal arrow as the key to the temporal arrow?

The second possibility is that the causal or 'production' arrow might ground the direction of time. Earman mentions this idea:

> T can be time reversal invariant although $T \vdash (E(x, y) \leftrightarrow R(x, y))$ where $[R(x, y)]$ is interpreted to mean that it is physically possible for events at x to cause events at y via causal signals. (1974: 28)

This is a large topic, but we can deal with it expeditiously. If the causal arrow is to play this role, it needs to be sufficiently objective and global to underpin a universal direction of time, and sufficiently linked other matters not only to be epistemologically accessible, but also to avoid the open question problem. What could the other matters be? If asymmetric boundary conditions, then we are back to the previous case. If the laws of physics, then there are two problems: first, the whole idea will collapse if the laws are T-symmetric, contrary to Earman's and Maudlin's intention to find a notion of direction of time not tied to failures of T-invariance; and second, lawlike violations of T-symmetry *are* vulnerable to the open question objection, as we've already noted.

The one remaining option seems to be to tie the causal arrow to the temporal perspective of observers and agents. This is a good move, in my view, because, as I've argued elsewhere – e.g., Price (1991, 1992a, 1992b, 1996, 2001), Price & Weslake (2010) – nothing else turns out to be capable of explaining the intuitive asymmetry of causation. But in the present context, it takes us to immediately to

[15]This conclusion is hardly surprising. Once we've seen why *up* and *down* are relative to our standpoint, we see that we wouldn't be tempted to regard *up* as any more objective, if everywhere except Antarctica became uninhabitable.

the question as to whether, constituitively or at least epistemologically, conscious experience plays a fundamental role in the case for a direction of time.

Conscious experience could only play this role if it itself is unidirectional, but this is precisely the assumption that Boltzmann challenges, in the passage we quoted earlier. Boltzmann offers us a picture of the universe in which not all conscious observers "point the same way" in time – some have the opposite orientation to us – and invites us to find it plausible that there can't be a fact of the matter about who gets it right. So a friend of the view that time has an objective direction – especially one who agrees that conscious experience plays a crucial role in making the case for this view – needs a response to Boltzmann.

3.10 Maudlin *v.* Boltzmann on 'backward brains'

Maudlin offers such a response, in recent work. Maudlin's immediate target is an argument by D. C. Williams (and a related argument by me). However, Williams's example is simply a philosophically-motivated version of Boltzmann's, so we may take Maudlin to be responding to Boltzmann, too. Here is Maudlin's characterisation of the Boltzmann–Williams argument:

> If we accept that the relevant physics is Time Reversal Invariant, then we accept that [our] time-reversed Doppelgänger is physically possible. Let's suppose, then, that such a Doppelgänger exists somewhere in the universe. What should we conclude about its mental life?
>
> The objector, of course, wants to conclude that the mental state of the Doppelgänger is, from a subjective viewpoint, just like ours. So just as we judge the 'direction of the passage to time' to go from our infant stage to our grey-haired, so too with the Doppelgänger. But that direction, for the Doppelgänger, is oppositely oriented to ours. So the Doppelgänger will judge that the temporal direction into the future points opposite to the way we judge it. And if we insist that there is a direction of time, and we know what it is, then we must say that the Doppelgänger is deceived, and has mistaken the direction of time. But now we become worried: the Doppelgänger seems to have exactly the same *evidence* about the direction of time as we do. So how do we know that (as it were) *we* are not the Doppelgängers, that we are not mistaken about the direction of time. If there *is* a direction of time, it would seem to become epistemically inaccessible. And at this point, it seems best to drop the idea of such a direction altogether. But is this correct? (2002: 271–272)

Maudlin now introduces a terminological convention, before offering his response to the Doppelgänger argument:

> In order to facilitate the discussion, I will refer to corresponding bits of the Doppelgänger with a simple modfication of the terms for parts of the original person. For example, I will speak of the Doppelgänger's neuron*s: these are just the bits of the Doppelgänger that correspond, under the obvious mapping, to the original's neurons. ...
>
> [G]iven the physical description of the Doppelgänger that we have, what can we conclude about its mental state? The answer, I think, is that we would have no reason whatsoever to believe that the Doppelgänger has a mental state at all. After all, the physical processes going on the Doppelgänger's brain* are quite unlike the processes going on in a normal brain. Nerve impulses* do not travel along dendrites to the cell body, which then fires a pulse out along the axon. Rather, pulses travel up the axon* to the cell body*, which (in a rather unpredictable way) sends pulses out along the dendrite*s. The visual system* of the Doppelgänger is also quite unusual: rather than absorbing light from the environment, the retina*s emit light out into the environment. (The emitted light is correlated with the environment in a way that would seem miraculous if we did not know how the physical state of the Doppelgänger was fixed: by time-reversing a normal person.) There is no reason to belabour the point: in every detail, the physical processes going on in the Doppelgänger are completely unlike any physical processes we have ever encountered or studied in a laboratory, quite unlike any biological processes we have ever met. We have *no reason whatsoever* to suppose that any mental state at all would [be] associated with the physical processes in the Doppelgänger. Given that the Doppelgänger anti-metabolises, etc., it is doubtful that it could even properly be called a living organism (rather than a living* organism*), much less a conscious living organism. (2002: 272–273)

However, it is easy to imagine an analogous argument against the claim that we might to expect to find conscious life, or any sort of life, on distant planets. After all, imagine a Doppelgänger of one of us, on Planet Zogg. Following Maudlin's example, let's use a superscript notation to denote bits of, and processes within, the Doppelgänger that correspond to bits and processes in us, under the obvious Zogg–Earth translation: the Doppelgänger thus has neurons^{z}, for example. The analogous argument now runs like this, with the obvious modifications to Maudlin's text:

> [T]he physical processes going on the Doppelgänger's brain^z are quite unlike the processes going on in a normal brain. Nerve impulses^z do not travel along dendrites to the cell body, which then fires a pulse out along the axon. Rather, [impulses^z travel^z along dendrites^z to the cell body^z, which then fires^z a pulse^z out along the axon^z.] ... There is no reason to belabour the point: in every detail, the physical processes going on in the Doppelgänger are completely unlike any physical processes we have ever encountered or studied in a laboratory, quite unlike any biological processes we have ever met. We have *no reason whatsoever* to suppose that any mental state at all would be associated with the physical processes in the Doppelgänger. Given that the Doppelgänger metabolises^z, etc., it is doubtful that it could even properly be called a living organism (rather than a living^z organism^z), much less a conscious living organism.

Why is this argument unconvincing? Essentially, because we regard spatial translation as a fundamental physical symmetry, *and therefore expect that it holds in biology and psychology, too.* Far from being "completely unlike any physical processes we have ever encountered," the processes in question are *exactly alike,* by the similarity standards embodied in the fundamental symmetries. It *could be* that these symmetries break down for life, or consciousness. But that would be a huge surprise, surely. And similarly for T or CPT symmetry. So far from having "no reason whatsoever to suppose that any mental state at all would be associated with the physical processes in the Doppelgänger", we have a reason grounded on an excellent general principle: physical symmetries carry over to the levels that supervene on physics.

Maudlin would reply, I think, that this appeal to the symmetries just begs the question against his view. If there is an objective direction of time it is surely part of physics – in which case physics is *not* T-reversal symmetric, and there's no failure of supervenience. The latter claims are correct, as far as they go, as are the analogous claims about spatial translation symmetry. If the position of the Earth is objectively distinguished, in the way imagined, then physics is *not* translation-invariant – a fact evidenced by the zombie-like nature of our Zoggian Doppelgängers. Again, there's no failure of supervenience involved in the huge mental difference between us and them, because it sits on top of a huge physical difference.

But let us be clear about the commitments of this position. Recall Maudlin's central example, that of an asteroid travelling between Mars and Earth. The passage of time is supposed to provide what it takes to make it the case that the asteroid is *actually* moving in one direction rather than the other. If we describe

the process without stipulating in which direction time is taken to be passing, we leave something out: our representation is incomplete. A familiar example of an incomplete representation in this context is that of a movie, which can be shown to an audience "forwards" or "backwards" – i.e. with either ordering of the frames. Let's call physical processes "time-blind" to the extent that their appearance in such a movie doesn't give the game away. So asteroid motion, in particular, is time-blind.

What else is time-blind? In particular, what about conscious experience? Here the defender of an objective direction of time faces a dilemma: either consciousness is time-blind, too, in which case the internal phenomenology "as of" an orientation in time doesn't *actually* fix the direction of a mental life; or there is a radical discontinuity between consciousness on the one hand, and ordinary physical systems, on the other. The former option undermines the claim that our conscious experience could be a guide to existence or orientation of a privileged direction of time; while the latter seems contrary to the spirit of physicalism, in the sense that it implies that there is something that can be detected by a conscious instrument that cannot be detected by a physical instrument.

Maudlin is willing to grasp the second horn of this dilemma, and he is not the first to do so. Eddington, too, came this way:

> The view here advocated is tantamount to an admission that consciousness, looking out through a private door, can learn by direct insight an underlying character of the world which physical measurements do not betray. (Eddington 1928: 91)

While such views don't violate the letter of physicalism, they are certainly unappealing to physicalist intuitions – spooky both on the side of physics, in requiring that there is an element of the physical world so secretive as to be detectable only by minds; and on the side of the theory of mind, in assuming that minds have the ability to detect a fundamental aspect of reality, detectable in no other way.[16]

True, "unappealing to physicalist intuitions" is very far from "untenable". But Maudlin himself wants to appeal to orthodoxy in philosophy of mind, so it does seem a fair point to use against him. Responding to the challenge in (Price 1996) that the Doppelgänger argument undermines an appeal to conscious experience in support of a flow of time, Maudlin says this:

> [T]he response to Price is even more stark. He imagines a Doppelgänger which is not just reversed in time, but a Doppelgänger in a

[16] A comparison might be with Eugene Wigner's view that it takes a conscious observer to collapse the wave packet in quantum mechanics. This proposal is unappealing to physicalist intuitions in a similar way.

> world *with no objective flow of time at all,* i.e. (according to his opponent) to a world in which there is no time at all, perhaps a purely spatial four-dimensional world. So it not just that the nerve pulse*s of this Doppelgänger go the wrong way (compared to normal nerve pulses), these nerve pulse*s don't go anywhere at all. Nothing happens in this world. True, there is a mapping from bits of this world to bits of our own, but (unless one already has begged the central question) the state of this world is so unlike the physical state of anything in our universe, that to suppose that there are mental states at all is completely unfounded. (Even pure functionalists, who suppose that mental states can supervene on all manner of physical substrate, use temporal notions in defining the relevant functional characterizations. Even pure functionalists would discern no mental states here.) (2002: 273–274)

This appeal to the authority of functionalists is optimistic, to say the least. Of course, functionalists "use temporal notions." But equally obviously, they don't do so (typically!) under the supposition that Maudlin makes here, that genuine temporality requires flow. If we insist on adding that supposition as a terminological stipulation, a typical functionalist will simply reformulate her view in non-temporal terms, to avoiding signing up for objective passage.

Indeed, if we want an example of a functionalist who is explicit about *not* signing up for Maudlin's picture – with its lawlike, unidirectional conception of time and causation – we need look no further than the greatest of them all. Here is David Lewis, giving us his view of the character of the causal asymmetry:

> Let me emphasize, once more, that the asymmetry of overdetermination is a contingent, *de facto* matter. Moreover, it may be a local matter, holding near here but not in remote parts of time and space. If so, then all that rests on it—the asymmetries of miracles, of counterfactual dependence, of causation and openness—may likewise be local and subject to exceptions. (1979: 475)

As for Maudlin's suggestion that my argument begs the question against the proponent of objective temporal flow, I think he is mistaken about the dialectic. My argument is a reply to the suggestion that temporal phenomenology provides reason to believe in an objective flow of time. It proceeds by pointing out that to whatever flow-invoking hypothesis is offered in explanation of the agreed temporal phenomenology, there's a parallel hypothesis – generated by an obvious mapping between underlying brain states as described in the flow picture and the corresponding brain states as described in the flowless picture – offering an explanation of the same phenomena *without* invoking flow.

Maudlin objects as if the flow-invoking hypothesis is already confirmed by direct experience, while its rival remains mere speculation. But this is not the relevant dialectical position at all. Rather, we need to suppose ourselves open-minded about whether there is flow, and hence in the business of considering hypotheses that might provide reason for coming down on one side or other. The situation is then as I claimed. The phenomena do not support the existence of flow, because – at least for a physicalist – any flow-invoking explanation of the phenomena is easily matched by a flowless explanation.

3.11 Summary

At the end of §3.8, I claimed to be at a loss to find *any* answer, in the abstract, to our question P0: What would it *be* for the world to come equipped with a time orientation? We then set out to investigate the issue from the (epistemological) ground up, by asking what kinds of T-asymmetry might provide evidence either for temporal anisotropy or (more problematically) for an objective temporal orientation. The answer to the latter part of this question has turned out to be Eddington's: if there is evidence for orientation, it lies in the special character of our temporal phenomenology. And in the light of Boltzmann's challenge, it must be held to be evidenced in no other way.

Thus we can say this much in answer to P0. For the world to come equipped with a time orientation *to which we have access* is for there to be some time-asymmetric "underlying character of the world" (as Eddington puts it), on which conscious experience provides "a private door". This helps a little with my puzzlement, in the sense that the box of options no longer seems entirely empty, but it is hardly satisfying. The proposal remains vulnerable to my version of the Doppelgänger objection – viz., that we have been offered no convincing argument that our temporal experience needs such an explanation (the role of the Doppelgänger being to generate "directionless" or "flowless" alternatives to any attempt to show how a direction or flow would explain the phenomenology). And it conflicts with physicalist intuitions, in the sense explained above. Eddington himself nails one aspect of this concern:

> The physicist, whose method of inquiry depends on sharpening up our sense organs by auxiliary apparatus of precision, naturally does not look kindly on private doors, through which all forms of superstitious fancy might enter unchecked. (1928: 91)

But, apt as it is, this characterisation makes the physicist, not the physicalist, the aggrieved party. The physicalist's concern is not that conscious experience tends to be an unreliable guide to nature, but that mind should thought of, *qua* object

rather than observer, as merely a *part* of physical nature. This commitment sits extremely uncomfortably with the view that there is a fundamental feature of the world to which only conscious minds are sensitive.

I conclude that while the proposal that time has an objective orientation is not incoherent, it is both (i) a long way out on a philosophical limb, in virtue of its conflict with physicalism; and (ii) entirely unsupported by its own claimed grounds, in virtue of the ready availability of alternative explanations of the relevant phenomenology. Hence it is hardly an appealing alternative to Boltzmann's view.

4 Objective flux?

The third ingredient of the "passage package" is the idea that time has a transitory, flux-like, or dynamic character, of a kind not captured by the spatialised conception of time that is prevalent in physics (and popular with opponents of objective passage). Usually, of course, this ingredient is bundled with the other two: the transition in question is thought of as that of a distinguished moment, and as possessing a particular orientation. The new ingredient of the bundle – the ingredient I take to be most characteristic of the notion of flux – is that it is something to which a *rate* may sensibly be attached. Time passes at a certain number of seconds per second.

For the purposes of this section, I want to detach this ingredient from the familiar bundle. If we could make sense of this flux-like character of time at all, I think we could make sense of a Boltzmann-friendly version of it, according to which it did not have a preferred direction (and did not require a distinguished present moment). That spare view is my target in this section. (It cannot be too spare, however – we are still looking for something that distinguishes time from space.)

4.1 Objections to flow

One objection to the coherency of the notion of flow of time (see, e.g., Price 1996, 13) turns on the fact that it is usually thought to have a preferred *direction.* The objection is then that other flows acquire their objective direction, if any, from that of time itself – think of Maudlin's asteroids. But if the flow of time is itself supposed to be constitutive of the direction of time, it needs to do double duty, so to speak, to provide its own direction.

I think this is a good objection, but in this context I take it to be outranked by the general discussion of objective direction in the previous section. For present purposes, and in keeping with my strategy of distinguishing the three key strands

in the usual conception of the passage of time, I want to put the issue of directionality to one side. What is now on the table is a notion of temporal flux that does not have a preferred direction, but merely an (undirected) rate. What can be said about that proposal?

In earlier work I characterised the "stock objection" to the *rate* of flow of time as follows:

> If it made sense to say that time flows then it would make sense to ask how fast it flows, which doesn't seem to be a sensible question. (1996: 13)

I went on to note that "[s]ome people reply that time flows at one second per second," but say that "even if we could live with the lack of other possibilities," there's a more basic problem. Before criticising the latter claim,[17] Maudlin offers this response to the original objection:

> What exactly is supposed to be objectionable about this answer? Price says we must 'live with the lack of other possibilities', which indeed we must: it is necessary, and, I suppose, a priori that if time passes at all, it passes at one second per second. But that hardly makes the answer either unintelligible or meaningless. Consider the notion of a fair rate of exchange between currencies. If one selects a standard set of items to be purchased, and has the costs of the items in various currencies, then one may define a fair rate of exchange between the currencies by equality of purchasing power: a fair exchange of euros for dollars is however many euros will purchase exactly what the given amount of dollars will purchase, and similarly for yen and yuan and so on. What, then, is a fair rate of exchange of dollars for dollars? Obviously, and necessarily, and a priori, one dollar per dollar. If you think that this answer is meaningless, imagine your reaction to an offer of exchange at any other rate. We do not need to 'live with' the lack of other possibilities: no objectionable concession is required. (2004: 112)

In reply to Maudlin's suggestion, consider a graph of the amount of money I give you in currency X, against the amount of money you give me in currency Y. On such a graph, there is straight line marking the fair rate of exchange: as Maudlin says, exchanges taking place at points on that line can be interpreted in terms of equal purchasing power. And when X and Y are the same currency, the slope of that line is 1.

[17] Which I won't try to defend here – in this respect, I now think, my bad.

So far, so good. But what are the two axes, in the temporal case? One (corresponding to the numerator) measures the amount of time passed between two times t_1 and t_2 (cf., e.g., the amount of fuel dispensed by a pump between two times t_1 and t_2); the other, corresponding to the denominator, measures the amount of time it takes for that amount of time to pass (cf., the amount of time taken for that amount of fuel to be dispensed – the amount of time between t_1 and t_2).

The problem is not that these amounts of time are necessarily, *a priori,* of equal length. The problem is that they are *the very same thing.* The claim about the rate is informative to the same degree that the following statement is informative:

> Taking the Hume Highway from Sydney to Melbourne, the traveller completes his journey at a rate of one yard per yard traversed. By the time Melbourne looms on the southern horizon, he has put behind him more than 500 miles, over a distance of the same magnitude.'

This tells us that Melbourne is more than 500 miles from Sydney (via the Hume Highway), but the reference to rate is entirely vacuous. We can inform travellers about the number of kangaroos, or fence posts, or public conveniences, they will encounter per mile of their journey. We cannot sensibly inform them of how many miles they will encounter per mile, for here there are not two things – a tally of kangaroos, say, and a tally of miles – but just one (the tally of miles). Maudlin's exchange rate example misses this point, because it provides two things to tally: the dollars you give me, and the dollars I give you.

In defence of Maudlin, one might say that triviality isn't a fault but a feature – isn't that the point of his comparison with the *fair* rate of exchange? Fine, but we've just seen that we can have spatial rates in the same (trivial) sense. What we were after was a notion of flow, or flux, which would capture what's supposed to be special about time. What we have been given is a notion of flow so thin that the only thing that distinguishes time and space is that in one case the progression is at one minute per minute, in the other case at one metre per metre – i.e., that in one case it is time, in the other case space!

5 Proving the pudding

I conclude that all three of the paths that seemed variously co-mingled in philosophical accounts of the flow of time – a distinguished present, an objective temporal direction, and a flux-like character, distinctive to time – are theoretical dead ends. In most cases, it is difficult to see what coherent sense can be made of these notions, let alone how they could be supported by evidence or argument.

This is good news for the alternative view of time – for *Boltzmann's Block,* as we might call it, to acknowledge Boltzmann's "keen" insight, that the block need have no preferred temporal direction. Lest we Boltzmannians should become complacent, however, I want to finish by stressing two respects in which the project is very far from complete. One of these tasks is familiar, the other less so. Both are crucial, in my view, and I think that together they should be setting the agenda for future research in philosophy of time.

5.1 The flow of time as a secondary quality

The familiar task is that of explaining the temporal character of conscious experience; explaining the phenomenology, in virtue of which the notion of the passage of time has such a powerful grip on us. If consciousness is not, as Eddington suggests, "looking out through a private door", at the "underlying [temporal] character of the world," what gives us the impression that it is doing so?

This is the project of explaining how the flow of time is a secondary quality – "resident solely in the sensitive body", as Galileo puts it,[18] rather than in the objective world. I have nothing to contribute to this project here, but I would like to record a conviction (wholly unoriginal) that at least part of the key lies in the illusion of a persisting self. In a sense, I think, this is a double illusion. First, there's the contribution so nicely nailed by Austin Dobson:

> TIME goes, you say? Ah no!
> Alas, Time stays, we go.[19]

In other words, we (mistakenly) treat ourselves as fixed points, and hence think of time as flowing past us.

But this illusion rests in turn on a deeper one; that of a single persisting self, self-identifying over time. I think that Jenann Ismael is correct about the origin of this deeper illusion, in treating it as what she calls a 'grammatical illusion', resting on an indexical 'abuse of notation':

> When I talk or think about myself, I talk or think about the connected, and more or less continuous, stream of mental life that includes this thought, expressing the tacit confidence that that is a uniquely identifying description (in the same way I might speak confidently of this river or this highway pointing at part of it, expressing the tacit assumption that it doesn't branch or merge), but it need not be. There is no enduring subject, present on every occasion of 'I'-use,

[18] *Il Saggiotore,* from a passage quoted by Burtt (1954: 85).

[19] Austin Dobson, 'The Paradox of Time': http://smcdaniel.net/mrmcd's/serendipty/time.html

> encountered in toto in different temporal contexts. The impression of a single thing reencountered across cycles of self-presentation is a grammatical illusion .... (2007: 186)

That is, in my view, a key ingredient in an understanding of the *flow of time* as a secondary quality, is an understanding of the *enduring self* as a secondary quality.[20]

5.2 Eddington's challenge

For the less familiar task, I return to Eddington. As I noted above, Eddington is well aware of the dangers of private doors:

> The physicist, whose method of inquiry depends on sharpening up our sense organs by auxiliary apparatus of precision, naturally does not look kindly on private doors, through which all forms of superstitious fancy might enter unchecked. (1928: 91)

But he counters with a challenge which I think his opponents – we friends of Boltzmann's Block – have ignored to our cost. The above passage continues like this:

> But is he [i.e., the physicist who renounces private doors] ready to forgo that knowledge of the going on of time which has reached us through the door, and content himself with the time inferred from sense-impressions which is emaciated of all dynamic quality?
>
> No doubt some will reply that they are content; to these I would say—Then show your good faith by reversing the dynamic quality of time (which you may freely do if it has no importance in Nature), and, just for a change, give us a picture of the universe passing from the more random to the less random state ... If you are an astronomer, tell how waves of light hurry in from the depths of space and condense on to stars; how the complex solar system unwinds itself into the evenness of a nebula. Is this the enlightened outlook which you wish to substitute for the first chapter of Genesis? If you genuinely believe that a contra-evolutionary theory is just as true and as significant as an evolutionary theory, surely it is time that a protest should be made against the entirely one-sided version currently taught. (1928: 91–92)

I want to make two responses to this challenge. The first is to note a respect in which it is a little unfair to Boltzmann's Block, or at least to Boltzmann himself

[20] See Ismael (this volume) for more on this project.

– in one respect, Boltzmann is ahead of Eddington, I think. But the second is to acknowledge that in other respects, Eddington makes a very important point. In general, friends of Boltzmann's Block have not done enough to free themselves from the shackles of the pre-Copernican viewpoint; and in the long run, the best case for Boltzmann's view would flow from the clear advantages of doing so (were such to be found).

Boltzmann is ahead of Eddington in offering us a picture in which the entropy gradient is a local matter in the universe as a whole, entirely absent in most eras and regions, and with no single preferred direction in those rare locations in which it is to be found. Combined with Eddington's own view that the asymmetries he challenges his opponent to consider reversing – asymmetries of inference and explanation, for example – have their origin in the entropy gradient, this means that Boltzmann has an immediate answer to the challenge. Of course we can't "[reverse] the dynamic quality of time" *around here,* for we live within the constraints of the entropy gradient in the region in which we are born. But we can tell you, in principle, how to find a region in the picture is properly reversed; and that shows that the fixity of our own perspective does not reflect a fundamental asymmetry in nature. Analogously (Boltzmann might add), the fact that men in Northern Europe cannot live with their feet pointed to the Pole Star does not prove a spatial anisotropy. If you want to live with your feet pointing that way, you simply need to move elsewhere.

Moreover, Eddington associates the entropy gradient directly with the "time of consciousness":

> It seems to me, therefore, that consciousness with its insistence on time's arrow and its rather erratic ideas of time measurement may be guided by entropy-clocks in some portion of the brain. ... Entropy-gradient is then the direct equivalent of the time of consciousness in both its aspects. (1928: 101)

So Boltzmann's hypothesis also threatens the veracity of Eddington's "private door".

In broader terms, however, Eddington's challenge has not been taken up. Most advocates of the 'no flow' view – even those explicit about the possibility that time might have no instrinsic direction – have not explored the question as to what insights might follow from Boltzmann's Copernican shift. I want to conclude with some remarks on this issue. It seems to me that there are at least three domains in which we might hope to vindicate Boltzmann's Copernican viewpoint, by exhibiting the advantages of the atemporal perspective it embodies.[21]

[21] For the benefit of young scholars reading this chapter in search of a thesis topic, I paraphrase Jehangir's famous tweet from Kashmir: "If time doth conceal a philosophers' prize; here it lies, here it lies, here it lies."

Cosmology. The first domain is that of cosmology. There are two aspects to the relevance of Boltzmann's viewpoint in this context. First, and closest to Boltzmann's own concerns, there is the project of understanding the origin of the entropy gradient, in our region. One of the great advances in physics over recent decades has been the realisation that this problem seems to turn on the question as to why gravitational entropy was low, early in the history of the known universe – in particular, why matter was smoothly distributed, to a very high degree, approximately 100,000 years after the Big Bang.[22] As we try to explain this feature of the early stages of the known universe, Boltzmann's hypothesis ought to alert us to the possibility that it is non-unique – ought to open our eyes to a new range of cosmological models, in which there is no single unique entropy gradient.

There is some work which takes this possibility seriously – see, e.g., Carroll and Chen (2004) and Carroll (2009, ch. 15). However, there is much more work in which it is either overlooked, or dismissed for what, with Boltzmann's symmetric viewpoint clearly in mind, can be seen to be fallacious reasons. For example, the possibility that entropy might decrease 'towards the future' is dismissed on statistical grounds, with no attempt to explain why this is a good argument towards the future, despite the fact that (i) it is manifestly a bad argument towards the past, and (ii) that the relevant statistical considerations are time-symmetric. (See Price (1996) for criticism of such temporal 'double standards', and the role of the timeless Copernican viewpoint in avoiding them.)

These considerations point in the direction of the second and broader aspect of the relevance of Boltzmann's Copernican viewpoint in cosmology. It alerts us to the possibility that the usual model of 'explanation-in-terms-of-initial-conditions' might simply be the wrong one to use in the cosmological context, where the features in need of explanation are larger and more inclusive than anything we encounter in the familiar region of our 'home' entropy gradient. Here, the point connects directly with Eddington's challenge, in the way noted above. We can concede our local practices of inference and explanation are properly time-asymmetric, as Eddington observes; while insisting that symmetry might prevail on a larger scale.

Modal metaphysics. Many *modal* properties and relations, such as chances, powers, dispositions, and relations of causal and counterfactual dependence, seem to exhibit a strong 'past-to-future' orientation. Sometimes this passes without

[22] See Penrose (1989), Price (1996, ch. 2; 2004; 2006), Albert (2001) and Carroll (2009) for expositions of this story. See Earman (2006) for some interesting criticism – though criticism largely defused, in my view, by the observation (cf. Price 2002, §1.2, 2006, §3.4) that the story in question does not need to be told in *thermodynamic* terms. It can be regarded as an *astrophysical* explanation of the existence of stars and galaxies (themselves by far the most striking manifestations of the entropy gradient, in our region).

comment, but sometimes it is presented as a philosophical puzzle, especially in the light of the apparent temporal symmetry of (most of) fundamental physics. A natural question is what we should say about these modal asymmetries in the context of Boltzmann's globally-symmetric viewpoint. Prima facie, there are several possibilities. We might try to maintain that the modal asymmetries are primitives, not dependent on the local entropy gradient, or the perspective of creatures whose own temporal viewpoint depends on that gradient, in Boltzmann's picture. But this will have the disturbing consequence that some of Boltzmann's intelligent observers will simply be *wrong* about the direction of these modal arrows – and how could we tell that it wasn't us?

For this reason, we might prefer to tie the modal asymmetries either directly to the local entropy gradient, or indirectly to it, by associating it with the temporal perspective or the observers and agents in question. But this has the consequence that – like the direction of time itself – the modal asymmetries are bound to a lot less fundamental than the pre-Copernican picture assumes, in Boltzmann's model. And this consequence may be of much more than merely philosophical interest, if these asymmetric modal notions are applied unreflectively in science. If their use does reflect a particular, contingent temporal perspective, then some parts of science – and physics, especially – may be less objective than they are usually assumed to be. So I think there is important work to be done on the relation of modal concepts and the temporal contingencies of our physical situation. Once again, the subject as a whole is still in its pre-Copernican phase, and Eddington's challenge goes largely unheeded.

Microphysics. Most interestingly of all, there is the possibility that the pre-Copernican viewpoint might be standing in the way of progress needed in fundamental physics – that is, that there might be explanations to which this viewpoint is at least a major obstacle, if not an impenetrable barrier. Here the most interesting candidate, in my view, is the project of realist interpretations and extensions of quantum mechanics. Discussions of hidden variable models normally take for granted that in any reasonable model, hidden states will be independent of future interactions to which the system in question might be subject. The spin of an electron will not depend on what spin measurements it might be subject to in the future, for example. Obviously, no one expects the same to be true in reverse. On the contrary, we take for granted that the state of the electron may depend on what has happened to it in the past. But how is this asymmetry to be justified, if the gross familiar asymmetries of inference, influence and explanation are to be associated with the entropy gradient, and this is a local matter? Are electrons subject to different laws in one region of the universe than in another, or "aware" of

the prevailing entropy gradient in their region? On the contrary, in Boltzmann's picture: we want microphysics to provide the universal background, on top of which the statistical asymmetries are superimposed.

This topic intersects closely with the last one. For it requires that we be careful about what we mean by the *state* of a physical system – careful that we don't simply take for granted a conception that cements in place the kind of time-asymmetric modal categories just mentioned. As I have noted elsewhere (Price, 1996: 250), we find it very natural to think of the state of a system in terms of its dispositions to respond to the range of circumstances it might encounter in the future. What we use state descriptions *for,* above all else, is predicting such counterfactual, or 'merely possible', responses. However, if we want to allow for the possibility that the present state is affected by future circumstances, this conception of the state will have to go, apparently. After all, if different future circumstances produce different present states, what sense can we make of the idea that the actual present state predicts the system's behaviour in a range of *possible* futures? If the future were different, the *actual* present state wouldn't be here to predict anything.

When we explore these issues, it might turn out that the apparently puzzling assumption that hidden variables cannot depend on future interactions is merely a manifestation of asymmetry of our modal notions – just a kind of perspectival gloss on underlying dynamical principles which are symmetric in themselves. If so, there would be no new *physical* mileage to be gained by adopting the Copernicam viewpoint. Certainly, we would understand better what belonged to the physics and what to our viewpoint, but no new physics would be on offer as a result.

However, the more intriguing possibility is that there is a new class of physical models on offer here – models which are being ignored not for any genuinely good reason, but only because they seem to conflict with our ordinary asymmetric perspective. If that's the case, and if the models presently excluded have the potential they seem to have in accounting for some of the puzzles of quantum mechanics, then Boltzmann's viewpoint will prove to be truly revolutionary; and Eddington's challenge will be well and truly met.[23]

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