Temporal Perspectives, Probabilities, and Openness

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Abstract

One way to interpret the difference between presentism and eternalism is perspectively. This view argues that from a perspective outside of time, we should adopt eternalism, and from a perspective embedded within time, we should be presentist. I will use the perspectival view to make two central claims about the probabilities in statistical mechanics. First, the perspectival view can help us respond to the challenge that these probabilities are merely epistemic, subjective, or anthropocentric. Second, we should treat the future as *metaphysically* open, due to both probabilities in statistical mechanics and the localised nature of the present.

Keywords: presentism; eternalism; perspectives; probabilities; thermodynamics; open future

1 Introduction

Whether all of time exists equally or whether just the present moment exists is a central question in the philosophy of time. It defines two opposing positions - eternalism and presentism respectively - that not only form the basis of the metaphysics of time but also influence how we understand related questions, such as the status of the future with respect to the present.

A more nuanced view, however, suggests that eternalism and presentism are not necessarily in conflict, but rather represent different vantage points. According to Savitt (2006), the apparent conflict between these positions arises from the assumption that the notion of 'existence' can be understood independently of a specified perspective; in actuality, we must first determine our perspective and then address the question of what exists. From a perspective outside of and external to time we quantify over all of time, as in

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eternalism. But from an internal perspective that is embedded within time, we can only quantify over the moment we are situated at.[2] There is no 'existence simpliciter' that can be specified absolutely, what exists depends on one's perspective.

Rovelli (2019) advances a similar view, proposing that a third option between eternalism and presentism can be found by considering the local nature of the present within the broader temporal framework. He, similarly to Savitt, suggests that the question of 'what is real?' is inadequate without the qualifier 'when'. This view, as well as Savitt's, also aligns with the notion of temporal becoming, where time's flow is understood through relative notions of becoming and the idea of an embedded perspective (Rovelli 2019; Ismael 2016a, b; Arthur 2019; Savitt 2009; Dieks 2006 among others).[3]

I will call this collection of views the perspectival view of time; they propose that this perspectival structure is part of the fundamental nature of time.[4] The works cited contain many arguments for *why* we should adopt this metaphysical model of time. I do not repeat these here. This paper instead aims to explore and develop the implications of the perspectival view and use it to make two interconnected claims (which are themselves motivating reasons to adopt the perspectival view). The first claim is that the perspectival view can help us respond to the challenge that thermodynamic probabilities are merely epistemic, subjective, or anthropocentric. This challenge arises because the probabilities are seen as representing our inability to determine the exact microstate of the world, which limits the metaphysical consequences that we can draw. Taking time itself as perspectival - and identifying how SM probabilities are tied to the embedded perspective - provides a natural way to justify why these probabilities should be seen as truly metaphysical and helps to strengthen existing accounts of probabilities (Ismael 2009; Strevens 2011;

[2]This is a form of non-standard presentism (Fine 2005; Pooley 2013), in which there is no single unique present but each moment is present relative to itself. This is implicit in Savitt and Rovelli's views.

[3]Most of these authors do not explicitly discuss the perspectival view of eternalism and presentism, however all express similar relational ideas about time that naturally fit into this framework.

[4] The group of views on temporal becoming have often been called tenseless passage, localised temporal becoming or temporal B-coming. I have adopted the moniker perspectival to emphasise the perspectival ontology that Savitt proposes rather than the notions of time's flow that are related to this. The perspectival view is also closely related to the A versus B-theoretic distinction, and some of the above authors frame it in these terms; but again I stick to the terminology of presentism/eternalism in keeping with Savitt and do not attempt to discuss the subtle differences between these two sets of distinctions.

Myrvold 2021). These accounts focus on showing that the probabilities in statistical mechanics are *objective* rather than subjective, but do comparatively little to address the concern that they are epistemic and anthropocentric. Focusing on our metaphysically view of time itself, rather than on particular features of the probabilities or on our account of laws (as some existing responses do (e.g. Eagle 2019)), offers a novel way of thinking about this problem.

The second claim is that if we adopt the perspectival view, we should see thermodynamic probabilities - as well as the structure of spacetime in special relativity - as rendering the future *metaphysically* open. Openness is normally associated with the framework of metaphysical indeterminacy, which is defined as indeterminacy in the world that is left over when all sources of epistemic or semantic vagueness are resolved. These parts of physics have previously been dismissed as a possible basis for an open future due to being seen as purely epistemic limits on what can be known and predicted; meaning that they are excluded as sources of metaphysical indeterminacy by definition. This cannot be maintained if we adopt the embedded perspective; based only on what exists in a localised presentist perspective these probabilities capture an important element of reality and the indeterminacy produced cannot be resolved as merely epistemic or semantic.

The main consequences of this sort of perspectival view that have been explored so far tend to focus on embedding an *agent* (e.g. Ismael 2016a, b; 2023; Deng 2013). Although Ismael sees the resulting openness as *objective* and her view is compatible with what is argued here, her focus on agents obscures this and leads to it being characterised as merely epistemic. The potential metaphysical consequences of the perspectival view have not been properly recognised.

The connection between the perspectival view and emergent levels of reality, and emergent theories in physics such as thermodynamics, has also not been previously explored, beyond how it might connect to an agent. To do this, we must build on the notion of an embedded perspective. Savitt and Rovelli consider a fairly straightforward distinction between embedded and external, which simply captures being located at a certain moment (and at a certain spatial location) versus describing the world from no particular spatiotemporal position. But being embedded into material reality entails more than that: one is also located at a particular level of reality with the capacity for certain kinds of

dynamic interactions. Although the main arguments of this paper follow from just the condition of localisation, I will also explore how a level-dependent present is a viable and compelling option that further strengthens the conclusions drawn.

I will first, in Section 2, lay out some options for how the embedded presentist perspective can be defined, arguing that it need not be agent-centric and introducing two central factors: locality and level-dependency. In Section 3, I look at why, even though the probabilities of statistical mechanics have been defended as objective, they are still dismissed as a source of metaphysical openness and assumed to be tied only to an agent-centric notions of openness (such as in Ismael (2023)). In Section 4, I will explore the link between the embedded perspective and the probabilities of statistical mechanics to establish the two main claims of the paper.

2 The Embedded Perspective

The external eternalist perspective - where all moments of time exist equally - is relatively straightforward and familiar, and it is often seen as the appropriate view for physics. It seeks to model the entirety of reality in an objective, all-encompassing manner without reference to any particular position.[5] This is appealing within physics as it removes the need to single out any particular moment of time as a privileged present (which very few elements of physics seem to support). Additionally, its presumed aperspectivity sidesteps concerns about our subjective experience unduly dominating our metaphysical conclusions.

The perspectival view, however, sees the eternalist perspective as just one way of modelling time and recognises that time looks different from other perspectives. When embedded within time, only what is contained in that embedded position exists. This is the more novel and contentious part of the view.

Despite its inherent incompleteness, the embedded perspective can provide valuable insights into familiar phenomena that are part of our experience of the world, many of which have proved hard to find in the external, eternalist view (such as the flow of time,

[5]The external, eternalist view seen as being independent of *any* perspective, rather than as a particular type of perspective. Here I will refer to it as a type of perspective, as Savitt does, but note that it is very different from the embedded perspective and cannot be occupied by any type of actual physical observer.

the difference between past and future, etc). Subjective experience is a strong motivator for looking at the embedded perspective: we are embedded within time, so it stands to reason that many of the experiences we have may be tied to that position. Indeed, Savitt indicates that one way to understand the perspectival view is as fusing together the scientific (external) and manifest (embedded) images of the world; both are needed for a full account of reality. Ismael (2016a, b; 2023), and similarly Deng (2013), also focus on adding the experiential time of an embedded *agent* into the block universe.

But the emphasis placed by these authors on explaining our situated experience can limit the impact the perspectival view can have for objective metaphysical claims. Although our experience is argued to latch onto objective physical features, it is ultimately anthropocentric and subjective. The embedded perspective of an agent can only tell us how things appear relative to that agent. We should not dismiss the embedded presentist perspective as being *inherently* subjective; defining an embedded position in terms of an agent is not the only option. In the rest of this section, I will sketch some alternative options for what an objective presentist perspective could be based on besides an agent. There are two main factors that constrain what an embedded position looks like: locality and level-dependence. The first comes from being embedded at a particular time and place, and deals with the constraints to presentism that come from special relativity. The second is more subtle, but recognises that different types of systems will be embedded at different levels of reality.

I do not aim to determine absolutely what the present should look like for the perspectival view to work. Instead I will discuss which of the current proposals for understanding presentism best captures the claim that the present is an objective embedded perspective, offering alternatives to the agent-centric view and showing that any type of system can occupy an embedded perspective.[6]

[6]It should be noted that Savitt and Rovelli do not make their views explicitly agent dependent in the way that Ismael and Deng do, despite Savitt's discussions of the manifest image mentioned here. Savitt and Rovelli's method for defining the present is discussed in the next section; but the addition of level-dependency is not mentioned by either of them.

2.1 Locality

To be embedded in time is to be embedded at a particular time and place. Both Savitt and Rovelli recognize this and incorporate it into their perspectival views. Additionally, to define an embedded present we must face the greatest challenge to presentism: special relativity. In a Newtonian spacetime, absolute simultaneity allowed for a 3-dimensional present to evolve forward in time, but this is no longer viable. Special relativity denies a simple notion of simultaneity and we must abandon the claim that the present is a 3-dimensional space which encompasses the entire universe. Special relativity prompts us to adopt a present that is locally specified and relative to a position in space (or a reference frame).[7]

So what defines a local present moment? There are various proposals for local definitions of the present that make use of the objective structure in relativity theory. In other work, Savitt (2009) proposes using *causal diamonds* (also called Alexandroff intervals) to define the extent of the present. Causal diamonds are the intersection of the past and future lightcones of two points along a worldline, creating a diamond shaped interval with a spatial and temporal extension between the two events (see also Arthur 2019; Ben-Yami 2019; Rovelli 2019). The two points can be the start and end of what we might think of as an event in ordinary language, this recognises that most intuitive definitions of the present are extended to some degree. It is also flexible and adjustable to the span of time you want to consider, for example it can define a narrow present such as the length of a conversation or something like the present era of history. It also allows us to consider how the present may have vague boundaries (Ben-Yami 2019).

This option has been the most explored by those advocating the perspectival view, with both Savitt and Rovelli making use of it. However, other options also exist. For example, *lightcone presentism* (which defines the present as the surface of the past lightcone associated with a point in spacetime) is a viable alternative.

Both lightcone presentism and causal diamonds offer forms of presentism that are localised but not subjective; while a conscious agent *can* be used to pick out a particular reference frame we can define a reference frame relative to any system or set of coordinates (in

[7]There are arguments that quantum mechanics still requires an absolute frame of reference and that this is a viable route for a more traditional form of presentism. I do not attempt to address this here.

pedagogical examples of special relativity it is common to talk about the reference frame of a rocket or of Earth). We have multiple options for defining a localised presentist perspective within special relativity without relying on an agent.

2.2 Emergent Levels of Reality

There is another factor of being embedded into reality that the options above do not capture: being embedded in reality means being some type of physical system with certain capacities for interacting with the world. These capacities determine what the world looks like from the perspective of that system and should therefore be taken into account when defining the embedded presentist perspective. The best way to do this is to look at which physical theories govern that system - some are best modelled quantum mechanically, others classically or thermodynamically (of course there is a great deal of overlap and often the same system is modelled in lots of different ways depending on what target phenomena needs to be explained).

Which theory best describes the system's behaviour also tells us what level of reality the system is embedded into. It is now widely recognised that different scientific theories describe different scales and are directed at different target phenomena. The emergentist project (Wallace 2013; Ladyman & Ross 2007), while certainly not universally accepted, has provided strong arguments for accepting that we have higher-level ontologies based on higher-level theories as well as a fundamental ontology (if there is a fundamental level at all). If presentism is understood as an embedded perspective, it must account for not only an object's physical location in time and space but also its level of reality, as determined by the theory that best explains its behaviour and interactions with the world.

Agent-centric views on the embedded present such as Ismael (2016a, b; 2023) and Deng (2013) implicitly deal with this by thinking about embedding an agent. The agent has certain capacities for action and access to certain information, this is dependent on the level of reality that everyday agents occupy - for example the information available and agential capacity is often connected to thermodynamics. But this can easily be generalised to see how we can define an embedded presentist perspective at any level and with reference to any type of physical system, not just human agents.

The most useful account of presentism for capturing this is Brading's (2013) empirical

presentism. According to this view, the present relative to a physical system consists of all systems with which it is dynamically interacting. The motivation behind this view is straightforward: interacting systems are those that can either affect or be affected by the system of interest, shaping its evolution. These interacting systems are directly relevant to the present state and behaviour of the system.

This view also provides a useful connection to formal accounts of emergence, where different levels of reality are defined in terms of the dynamical equations that operate in each level (e.g. thermodynamics versus statistical mechanics, quantum versus classical dynamics etc - see Franklin & Robertson 2022). This naturally makes the empirical present level-dependent as it relies on the dynamics of a system.

According to Brading's empirical presentism, only facts relevant to a system's dynamical interaction are considered present. For example, she discusses how a mother texting her son considers him present relative to her. But any facts about what he is doing that go beyond what is revealed in the texts are not specified as part of *her* present as they are not relevant to her behaviour (although they will be part of her son's present, presentness is not transitive in this view). This is an agent-centric example, which I am attempting to move away from, however empirical presentism works perfectly well for any type of system. It is perfectly common in physics to consider localised, semi-isolated systems with limited dynamical interactions. Although Brading does not explore this explicitly, empirical presentism can be connected to emergent levels of reality. Many of the microscopic details of a system are irrelevant to its overall dynamical behaviour at the macroscopic level (Brading's molecular or atomic make-up isn't needed to describe her conversation with her son). The emergence literature calls this *conditional irrelevance*, where we can abstract from microscopic details and just use an coarse-grained macroscopic description of a system to effectively model its dynamics (Woodward 2021; Franklin & Robertson 2022). A system's *own* microstate is often irrelevant to its dynamics and should not be counted as present. This is admittedly a strong claim, but it follows from the formulation of empirical presentism and recognizes that different levels of reality provide novel descriptions of the same systems (I will explore this further in Section 4.2). The aim of the emergentist project has been to argue that we should make claims about ontology based on these novel higher-level descriptions as well as the lower-level descriptions. As

a result, when asking 'what exists' we should include macroscopic objects such as tables and chairs as well as fundamental particles; similarly we should distinguish between what exists in a macroscopic presentist perspective and a microscopic one.

This is not a definitive survey of all possible options for defining an embedded presentist perspective; however, it indicates that there are many viable ways to define an embedded perspective that are independent of a subjective agent. Whatever version one chooses to adopt, two main factors should be applied: locality and level-dependence. For the rest of this paper I will assume the embedded presentist perspective is defined according to empirical presentism as it is the best option for capturing both localisation and level-dependency, but the arguments presented do not rest on this view.

3 Probabilities and Openness

Having established that the perspectival view is not necessarily agent-dependent, I now focus on its implications for statistical mechanics. Specifically, I argue that the perspectival view can strengthen our understanding of the probabilities in statistical mechanics and that these probabilities render the future open in a strong metaphysical sense. Before looking at the positive arguments for this conclusion in the next section, I will first explore the current status of the probabilities in statistical mechanics and the reasons why they are generally *not* taken as a source of genuine metaphysical openness.

Probabilities in statistical mechanics are not fundamental, and are often interpreted as being subjective, epistemic and anthropocentric. They are taken to represent our inability to determine the exact microstate: without knowledge of the microstate we are forced to use probability distributions that represent our ignorance of the exact state.

Several accounts have been developed that aim to show that these probabilities are *objective* parts of the world, even if they have an epistemic gloss (calling them epistemic chances or objectified credences). Ismael (2009) argues that probabilities are relative to our knowledge of well-defined physical macrostates and that they are an indispensable part of physics. Myrvold (2021) and Strevens (2011) base their accounts of probabilities on features like the dynamics of the system or ineliminable noise at the microscopic level that makes the exact initial microstate - or even the initial probability distribution we

assign to a system based on our knowledge - irrelevant to predictions.

It is also possible that probabilities in statistical mechanics come from quantum mechanical probabilities. This is an open question (see Popescu et al. (2005) and the accounts mentioned above for more details). There is still debate about how to interpret quantum probabilities themselves, but they are generally taken as the most objective probabilities one could get in the world. But regardless of a possible reduction to quantum mechanics, the objectivity of thermodynamics (and its reduction to statistical mechanics) has been extensively defended in the literature on emergence and reduction in physics. This is at odds with claiming that thermodynamics does not reveal any objective metaphysical structure.

Of particular interest here is the defence offered by Robertson and Prunkl (2023), which picks up on the information theoretic basis to thermodynamics. They argue that a realist and objective interpretation is perfectly possible because, even in places where thermodynamics (and statistical mechanics) explicitly uses epistemic concepts, these are taken to link to objective physical structure in the world. They claim that thermodynamics captures the possible operations of agents and the possible ways we can manipulate systems, in the same way that information theory more generally is designed to do. These limits are objective parts of the world, and although they refer to the capabilities of an agent, this is a hypothetical idealised agent rather than any actual agent (who would have additional constraints depending on their subjective knowledge and the technology available to them). They conclude that "thermodynamics might not be fundamental, but it is objective" (Robertson & Prunkl 2023, pg 9).

However, despite rigorous defences of the *objectivity* of the probabilities in statistical mechanics, comparatively little has been done to show that these probabilities are not *epistemic* or *anthropocentric*. Robertson and Prunkl's defence still centres around agents - even they are hypothetical idealised ones - and the accounts of probabilities from Ismael, Myrvold and Strevens focus on showing why our ignorance is not a barrier to making effective predictions and demonstrating that science has objective ways around this, but they still ultimately accept that the probabilities are epistemic in some way. As a result, although the explanatory value of probabilities in statistical mechanics is well-respected in philosophy of science, it has had limited impact in metaphysics.

One of the main metaphysical implications associated with probabilities in physics is the idea that the future is metaphysically open. For many (e.g. Broad 1923; Pooley 2013), the actualisation of a non-existent open future is the key to understanding the metaphysics of time (although the openness of the future does not follow necessarily from presentism, and presentism in its original form did not endorse it - it is more often connected with growing block models of time). The difference between the past and the future is that the future is uncertain and there are many possible ways the world could turn out to be. Various models of the open future have been developed (Pooley 2013; Belnap 2012; Placek & Belnap 2012), each offering a different approach to explicating the ontological status of the future. Mostly, however, these views do not address what the source of openness is, they take openness as a given and ask what this means for the ontology of time.

Attempts to find the source of openness and define precisely what it *means* for the future to be open predominantly focus on the truth values of future contingents (statements in the present about what will happen in the future). Mariani and Torrengo specify an *adequacy condition* that any theory involving an open future must commit to: "Assuming that there is some qualitative variation across time, future contingents are unsettled with respect to their determinate truth value" (2021, pg. 3926). Unsettled must then in turn be defined, this can be done by thinking about possibility (see discussion, and objections, in Eagle 2019) or in terms of *metaphysical indeterminacy* (Barnes & Cameron 2009, 2011; Wilson 2013; Mariani & Torrengo 2021a). For the most part, the details of these views (such as whether they maintain bivalency) go beyond what is needed for the current argument. What all these views share is the claim that these truth values are unsettled because the present state of the world, together with the relevant laws, cannot determine a unique future. This indeterminacy is metaphysical when it remains after all sources of epistemic and semantic indeterminacy have been resolved (i.e. we know all the facts there are to know, have clearly defined our terms, and specified what they apply to). Thinking about what can be determined based on an initial state and relevant laws is essentially thinking about what is predictable. This must, however, be sharply separated from an *epistemic* notion of prediction. Epistemic prediction concerns what we can say about the future taking into account the limits of our knowledge and computational capabilities; this would not be *metaphysical*. Instead, the failure to determine the future reflects a deeper unpredictability arising from metaphysical indeterminacy in what the present state of the

world is, indeterministic laws, or indeterminacy in which laws obtain.

Given this understanding of openness, the probabilities of statistical mechanics cannot be taken to indicate a metaphysically open future. Even if they have been defended as objective, their non-fundamental, anthropocentric, and *epistemic* nature rules them out and prevents them from being used to draw metaphysical conclusions. If we have deterministic microscopic laws and have all the facts about the microstate of the world then the future is uniquely determined and future contingents have determinate truth values.

One line of response to this argument, which attempts to reconcile deterministic laws with chance in statistical mechanics, is to look at our metaphysics of laws (Barnes & Cameron 2009; Eagle 2019). Some accounts of laws, and how the laws rely on facts about what occurs in the future, allow for a compatibalist argument between determinism and an open future. This approach has potential, but is dependent on the specific account of laws and, as Eagle notes, comes with various drawbacks. In this paper, I will put aside this line of thought and focus not on the laws but on the present state of the world and what facts we take to be included in this. This is where thinking about being embedded within time can provide a novel alternative to these compatibalist arguments.

Even if we take the laws as fixed, we can still fail to have a determinate future if the initial state does not contain all the necessary facts. Attempts to explore this option have predominantly focused on quantum mechanics and indeterminacy in the present quantum state (Grandjean 2022; Mariani & Torrengo 2021a, b).[8] For example, Mariani and Torrengo argue that in spontaneous collapse interpretations of quantum mechanics there is indeterminacy in the present state of the world that entails the unsettledness of future contingents.[9] The assumption made in these views is that indeterminateness must be in the fundamental state of the world for it to count as genuinely *metaphysical*. The probabilities in quantum mechanics are a symptom of this indeterminacy (although probabilities alone do not necessarily constitute openness, as is evident from the probabilities of statistical mechanics). Higher-level physics may fail to uniquely determine the future, but this is seen as merely epistemic uncertainty arising from limits on our knowledge of

[8]This is tied up with the question of whether quantum mechanics has indeterministic laws.

[9]Grandjean alternatively focuses on the causal sets approach to quantum gravity.

the present state and our computational capabilities.

There has been one attempt to outline how considering being embedded in time could justify an open future . Ismael (2023) argues that the future is open due to paradoxes between how we represent the world and our role as agents in it (although this need not necessarily be construed as a *human* agent as opposed to an artificial one with similar capabilities). However, despite arguing that this openness is objective, Ismael does not address the charge of being epistemic and accepts openness as an agent-dependent feature.

Ismael's argument stems from the fact that an agent has to describe the world in order to theorise about it, and they inevitably have to include themselves in the description. Ismael argues that day-to-day physics avoids this issue because its goal is to model other systems. Even cosmology "maintains the imaginative fiction that we are sitting outside of the universe looking down." (Ismael 2023, p.1).[10] However, a complete representation of the universe must include the agent embedded in it and from this comes paradoxes of self-reference. Ismael's example of such a paradox is to imagine a computer that can be asked any question about the physical world. It is equipped with the necessary knowledge of the state of the world and the laws of physics to be able to answer, and its answer will appear in its output channel. There is a simple question that the computer will be unable to answer truthfully regardless of what knowledge it has: 'Is the answer to this question that's about to be displayed in the output channel 'no'?'. The computer cannot answer this truthfully because its actions in the world (printing the answer in the output channel) interfere with its ability to make predictions. This leaves open a number of potential futures that the actions of agents in the world can bring about. This is, however, a limit on *representation* and not on the world itself; it occurs at the level of experience:

> "This isn't going to affect what the system can do at a *physical* level. It does place constraints on what the system can truthfully represent and it does lead to an essential incompleteness in the worldview of an embedded Agent."

[10]Ismael does not explicitly mention the perspectival view in her arguments about the open future, however she is a proponent of a version of this view elsewhere (Ismael 2016a, b) and comments such as this suggest that this is in the background of her thought (although her version of the perspectival view focuses on the A versus B-theoretic distinction rather than the presentist/eternalist distinction that Savitt uses, see fn. 4)

(Ismael 2023, p.9)(emphasis in original)

Ismael points out that this works against the backdrop of the epistemic asymmetry. Our knowledge of the past (and lack of knowledge of the future) are the basis for the way we deliberate and act. The epistemic asymmetry has a strong physical basis in statistical physics and for this she follows Albert's (2000) account of the arrow of time in SM. Albert, along with Loewer (2023) and Fernandes (2023), argues that how an agent operates is constrained by the epistemic asymmetry that exists as a result of the asymmetry of thermodynamics.

All of this feeds into a picture where the future is open and subject to an agent's control, and this is closely connected to statistical mechanics. This openness is *objective*, due to its basis is statistical mechanics, but ultimately Ismael's emphasis on the representational level makes it hard to interpret it as metaphysical openness according to the accounts of metaphysical indeterminacy. The probabilities of statistical mechanics play merely a supporting role (albeit an essential one), they do not constitute openness in their own right.

It is certainly true that our experience of time goes beyond just a lack of knowledge of the future. The sense of control is hugely important and undoubtedly contributes to a complete and thorough explanation of our experience of time. But restricting openness entirely to this agent-centric notion, or insisting that openness comes only from the fundamental quantum level, is a mistake; the probabilities of statistical mechanics are a hugely important part of physics in their own right. Understanding the embedded present, not as an agent-centric idea but as a metaphysical perspective, gives us the means to elevate the probabilities in statistical mechanics from epistemic to metaphysical. It makes Ismael's narrow concept of agent-relative openness just a special case of a much wider metaphysical openness and strengthens our accounts of probabilities by showing how they can be not just objective but metaphysical.

4 Openness from the Presentist Perspective

I now turn to how the embedded presentist perspective relates to the probabilities in statistical mechanics. I will show that based on a localised, level-dependent present, together

with any relevant laws, we cannot settle the truth values of future contingents beyond what the probabilities of statistical mechanics allow us to predict. This will establish the two central claims of this paper: 1) the perspectival view strengthens our accounts of probabilities in statistical mechanics by providing a response to the objection that they are merely epistemic and anthropocentric, and 2) as a result they should be seen as rendering the future metaphysically open.

First, however, I will consider locality and the lightcone structure of spacetime on its own. The locality of the present has been one of the most radical consequences of special relativity and the lightcone structure of spacetime has frequently, as mentioned above, been used to characterise the open future (Pooley (2013), for example, gives a thorough presentation of such a view). Yet the lightcone structure is not commonly viewed as a genuine source of metaphysical openness, merely as a way to understand how openness works in relativistic spacetime. Showing that this is not the case - and that a localised present is grounds to consider the future to be indeterminate - is a comparatively straightforward but powerful case that paves the way for the discussion of probabilities in statistical mechanics.

4.1 Locality and the Lightcone Structure

The openness of the future depends on whether the present, combined with the relevant laws, can determine a unique future. Probabilities in physics are one symptom of a failure to do so, both in the quantum case and, as I will argue in the next section, in statistical mechanics. However, at a more basic level, this comes down to what facts we take to be included in the present state.

Relativity theory has led to a radical revision of our notion of the present: it is now widely accepted that the present is *local* (even if it is extended to some degree, such as through the use of causal diamonds). We can no longer rely on a simplistic notion of simultaneity and are forced to look to more complex definitions of the present as laid out in Section 2. In the wake of this, there is no reason to use a hypersurface covering the whole universe to assess what future contingents are settled and unsettled. We should instead ask what is settled based on a *localised* present (and what is in the past lightcone of this localised present). If the universal hypersurface is largely meaningless and rejected as a viable

definition of the present then it should not be given such importance in deciding issues such as the openness of the future.

Even if the localised present contains no fundamental indeterminacy about what state of affairs obtains in that localised area (and we are not dealing with probabilistic laws such as quantum or statistical mechanics) the limited set of facts in the localised present renders the future unpredictable. This unpredictability is not *merely epistemic*; it is not due to human limitations on what can be known and Section 2 established that we can define a localised present without reference to an agent. Even if we know every fact that is true in the localised present and assume that we have the computational power to apply fully deterministic laws, we still cannot uniquely specify the future and as such at least some future contingents will be left unsettled. There are always unspecified factors currently lying outside the local present (and outside of its past lightcone) that could influence what occurs in the future.[11] [12] This indeterminateness of the future cannot be resolved by addressing these epistemic concerns and must therefore count as genuine metaphysical indeterminacy.

The lightcone is integral to thinking about the causal structure of the world, among many other things, and we should no more dismiss the limits it puts on determining the future than we should dismiss its impact on our understanding of causation. Nor can this be dismissed as a *merely* epistemic limit. Once we adopt the localised present as part of our metaphysics of time, then this limit becomes part of our metaphysics as well. From the embedded presentist perspective, only the local present exists, and this alone can be used to make predictions. This is part of the structure of reality and not just a consequence of our limited agential capabilities.

[11] We can also think of facts outside of the localised present as being metaphysically indeterminate themselves, as the truth values about these parts of the world are not settled by what is contained within the localised present either.

[12] It is important to note that we are referring to the past lightcone of the current present event and not of the past lightcone of the future event we are trying to predict. Special relativity is extremely hospitable to deterministic laws in the sense that a cross section of the past lightcone of the event we are trying to predict is enough to predict it with certainty without looking at a full hypersurface.

4.2 Probabilities in Statistical Mechanics

Moving now to statistical mechanics: the probabilities in statistical mechanics indicate a failure to determine the future. Statistical mechanics cannot specify a single unique future relative to an initial macro-condition but instead gives a probability distribution over possible future states (and indeed, the present state itself is represented by a probability distribution[13]). Given that these probabilities are robust, objective, and explanatorily powerful, the final barrier that prevents these probabilities from being accepted as a basis for the open future is the assumption that a lower-level theory *does* specify a unique future, and this covers any failures of predictability within the higher-level theory. We are forced to use the less detailed, probabilistic higher-level theory only because we lack the necessary knowledge of the microstate (and the computational ability) required to use the lower-level theory. This is what characterises the probabilities as epistemic and anthropocentric (even if they are objective).

For a simple specification of the present as a universal hypersurface this is true; when we give the present state of the world we often mean the fully detailed microstate and as a result failures of predictability in higher-level theories do not matter. However, if we adopt the embedded presentist perspective, this does not obviously follow and we cannot presume that the microstate will fill gaps left in what can be settled by the higher-level theory. As Section 2 argued, two factors come from defining the present as an embedded perspective: locality and level-dependence. These two factors combine to make theories such as statistical mechanics (and thermodynamics) more predictively powerful from a localised perspective than microscopic dynamical laws are. As such, any future contingents that statistical mechanics fails to settle the truth values of should be taken as a sign of metaphysically indeterminateness.

First, consider the more contentious claim that the present is level-dependent, as in Brading's empirical presentism. Once we recognise that the embedded presentist perspective is situated at a specific level of reality, then the claim that the microstate fills in any gaps in prediction left by the macrostate no longer holds. What is *present* is relative to a specific level; the embedded perspective at the macroscopic level is not the same as the

[13]What exactly this probability distribution represents differs depending on your approach (for example Boltzmannian versus Gibbsian) to statistical mechanics. This is not relevant to the current argument.

embedded perspective at the microscopic level. Hearkening back to the introduction, both Savitt and Rovelli emphasise that a major flaw of the presentism vs eternalism debate has been to assume that we can answer questions such as 'what exists?' without first specifying the domain; we must say first whether we are considering all of time or just a single moment. Similarly we must also specify what dynamical level is relevant to the embedded system before asking what facts can be settled; facts about other levels are not necessarily included in what exists in any given perspective.[14] The definition of the present given in Brading's empirical presentism is naturally level-dependent and excludes the microstate from what is present relative to a given macroscopic system, although this does not necessarily follow from definitions of the present such as causal diamonds and lightcone presentism.

Second, considering locality (echoing the arguments of Section 4.1). Locality means that the present is no longer defined as a universal hypersurface but is based on a localised structure (as discussed in Section 2). Influences from outside the lightcone are not contained in the present and cannot be taken into consideration when predicting the future, so even the fully detailed microstate of a localised present will not deterministically predict the future.

Regardless of whether we accept that our definition of the present is level-dependent in and of itself, locality alone is sufficient to imply that higher-level theories acting on macrostates often settle more facts than what can be determined by deterministic microscopic laws acting on a localised microstate. Emergent laws and probabilities at the higher level are particularly relevant when considering localised systems. In part, this is because the target of many emergent laws is the behaviour of semi-isolated subsystems of the universe. Classic examples of what we use thermodynamics to explain are things like why my cup of tea cooled down, or how a car engine works, etc. (Although, this is definitely not an absolute limit on what falls into the domain of thermodynamics. We *do* also consider the thermodynamics of the universe, for example in the arrow of time literature, but even there we find debate over how a universal arrow relates to the asymmetry of subsystems.) Appealing to the microstate of the universe is unintuitive when looking for an explanation for why all cups of tea exhibit similar behaviour across a range

[14]This is somewhat reminiscent of Eagle's (2019) contextual chance argument but with a stronger metaphysical basis.

of circumstances; we want an explanation that latches onto local details that all these instances have in common. Predominantly considering subsystems does not *rule out* using fundamental laws as these too can be applied to sufficiently isolated localised systems, and emergent laws will be constrained to the information in the localised present just as much as the fundamental laws are. However, emergent laws have better apparatus to deal with localisation. Myrvold (2021) frequently makes reference to isolated systems - i.e. localised subsystems of the universe - in his account of probabilities. Ismael (2009) explicitly considers localisation as a factor in the introduction of probabilities, she says:

> "Even in a deterministic context, in which there is only a single trajectory through every point in phase space, unless we know the state of the universe as a whole with perfect precision, probabilities are unavoidable. In practice one is warranted in ignoring most of the universe when considering the state of a local system because she has a probability distribution, at least implicit, that assigns a low probability to distorting influences from other parts of the world" (Ismael 2009, pg. 94)

When fundamental laws are used on local systems it is normally in the context of highly idealised models that remove any outside influences (such as assuming no noise, no gravitational influences from outside the system etc). For any complex system even semi-isolation is unlikely; emergent laws are specifically designed to recognise that the system is open and to disregard irrelevant lower-level details and minor influences from outside the system (see Franklin & Robertson 2022; Wallace 2013).

There is an undeniable connection between statistical mechanics and the localized, level-dependent presentist perspective. In the embedded perspective, statistical mechanics often provides the best predictions for the future. A deterministic theory acting on the microstate of a localized present fails to resolve uncertainties left open by higher-level theories. Therefore, the probabilities in statistical mechanics reflect a genuine unsettledness, indicating the metaphysical openness of the future. This openness is perspectival, relative to a given system or position; but given relativity theory, an absolute distinction between past and future is incoherent as it is always localized. Thus, perspectival openness accurately captures the structure of time and aligns with our best physics.

4.3 Metaphysical Probabilities

The goal of this paper was to make two claims: first, the perspectival view can help to strengthen our accounts of probabilities in statistical mechanics and second, these probabilities render the future metaphysically open. The preceding sections focus on the second claim, while providing implicit support for the first. I will now address the first claim explicitly.

The accounts of probabilities from Ismael (2009), Strevens (2011) and Myrvold (2021) focus on proving that the probabilities are objective but still leave open the possibility that they are epistemic and anthropocentric. If we take a standard eternalist view of time then this conclusion is hard to avoid. A standard eternalist has to explain how a statement at t_1 such as 'x occurs at t_2 with probability $\frac{1}{2}$' can be true despite 'x occurs at t_2' also being true (made true by the actual state of affairs at t_2 or by a fully detailed microstate of the universe at t_1 that deterministically predicts that x will occur at t_2). In the eternalist world-view all times exist equally and all facts are on the same footing, so there is a direct conflict. This conflict between these facts can only be resolved by labelling one fact (the probabilistic one) as merely epistemic.

Of course, an eternalist *can* still make sense of probabilities by recognising that they are relative to a specific time. This is what they must do for quantum probabilities anyway. But even then there is a further conflict between the probabilities based on the macrostate at t_1 and the deterministic prediction based on the microstate at t_1. This cannot be explained away as a result of indeterministic laws in the way quantum probabilities can. In addition, there is the question of *why* we are restricting ourselves to consider what facts are settled relative to specific time. This relativism is at odds with the premise of eternalism and makes use of some notion of being embedded within time without specifying what this means. A standard eternalist can explain probabilities only by considering them as a consequence of limiting the available information in the block universe (i.e. we restrict to the subset of facts available in that spacetime region at the relevant level and assessing what future contingents are settled based on that). This does not necessarily mean they cannot view emergent structure, including the probabilities of statistical mechanics, as objective and important; but it makes the accounts of probabilities much weaker and more epistemically inclined. No justification is given for what it means to restrict ourselves to

the present moment or why we are motivated to do this. And no consideration is given to how we define the present moment. The main recognisable reason for making this restriction is thinking about *what an agent could know*; as such, it becomes natural to characterise probabilities in statistical mechanics as resulting from an agent's ignorance.[15]

In contrast, the embedded presentist perspective provides a natural basis for the probabilities in statistical mechanics. The perspectival view builds the restriction to a certain spacetime region and a certain level into the metaphysical structure of time and recognises it from the start as an essential aspect of reality. As Section 2 shows, the embedded perspective is not tied to an agent and the perspectival view gives proper attention to how we define the present moment relative to a given embedded system. The result of the perspectival structure of time is that certain claims about the future are genuinely indeterminate from the embedded perspective and the objectivity of these probabilities is no surprise. For probabilities, the statement at t_1 that 'x occurs at t_2 with probability $\frac{1}{2}$' is made true by a macrostate that defines this probability in the relevant embedded perspective. This is the best possible prediction of the future from that perspective. The perspectival view allows for both this statement and the statement that 'x occurs at t_2' to be true *from different perspectives* without them coming into conflict. Acknowledging perspectives as an unavoidable aspect of reality makes it much clearer why emergent theories have so much novel explanatory value and shows how we can avoid thinking of them as anthropocentric. This does not remove the need for accounts of probabilities such as Ismael's (2009), Myrvold's (2021) or Strevens' (2011) but supports them. We still need these accounts to show how probabilities are linked to emergent levels within physics and how they are independent of the microstate, which the perspectival view takes as a given. But the perspectival view removes the questions about why such structure is metaphysically important and why it should not be dismissed as anthropocentric or epistemic. This approach allows us to argue that probabilities are not merely objective but also metaphysical..

[15]Compatibalist approaches to reconciling genuine chance in statistical mechanics with determinism, such as Eagle (2019), take an essentially eternalist view of time and do just this. They focus on how our reductionist accounts of laws (like the best system account) rely on regularities in events across all of space and time, including events in the future. When we restrict ourselves to thinking about just the events in the present and past, it can therefore be unsettled what exactly the laws are (Eagle explores the nuances of this argument depending on which account of laws is followed).

This all comes down to how we think about the embedded perspective. By moving away from an agent-centric notion of embeddedness, as laid out in Section 2, we get a metaphysics that reflects perspectival structure in the world and gives a clear meaning to the limits this places on what information we have available for physical explanations at any given place. To explain the possible ways in which a localised system might evolve, we focus on that system and other local facts that are available rather than making an appeal to the deterministic microscopic evolution of the universe that is far removed from the matters at hand. A localised version of presentism implies that all that exists - from that position - are those local facts, making them a natural and indeed the only possible basis for explanation.

5 Conclusion

This paper began with two claims: first, adopting a perspectival view strengthens our understanding of probabilities, showing they are not just objective but also metaphysical. This counters the argument that probabilities are purely epistemic or anthropocentric. Second, we should view these probabilities and localised nature of the present as rendering the future metaphysically open.

Discussions of the open future that focus solely on quantum mechanics or look to our metaphysical accounts of laws overlook the broader complexity of defining the present moment. The perspectival view is a metaphysical model of time that pays proper attention to this question; it provides a coherent framework for thinking about what it means to be embedded within time and to assess future contingents relative to that position.

I have not explored in depth the reasons to accept the perspectival view as our model of time, but arguments for this can be found in (for example) Savitt (2006; 2009), Rovelli (2019), Ismael (2016a, b), Arthur 2019 and Dieks (2006). Additionally, the fact that the perspectival view strengthens the explanatory power of statistical mechanics and supports the argument that it provides objective metaphysical probabilities is, in itself, a compelling reason to consider the perspectival view.

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