The Search for Time: a New Definition of Information

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> Nothing is more human than the desire to transcend our humanity.
>
> — Huw Price

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To Carl

I will take you wherever I go

And I you

1 Introduction

There is a longstanding tradition of thinking about time from an objective, or a subjective lens, as an explainable phenomenon and not merely as a brute fact. Until now, the best way to avoid slipping into the brute fact way of thinking and determine a direction of time is by reducing time to entropy. We must ask ourselves, is this an appropriate inference? Can we meaningfully reduce time's direction to entropic change? In this paper, I shall focus on the objective aspect and argue that entropy, and its inverse relation to information, is not sufficient for establishing a direction of time; we need a second kind of information, i.e. information about "information change". I will argue against the traditional definition of time as reduced to entropy and instead argue for a non-traditional and novel account of time that will define universal temporal asymmetry. I shall discuss traditional descriptions of time to focus on the thermodynamic and informational account, delve into Reichenbach's account of how to tell time, and then provide a non-traditional definition of time and information. I will introduce a universal observer, defining a second kind of information not found in traditional the discourse.

Our intuitive anthropic notion of time does not match physical descriptions in symmetry, and the lack of a *now* that is so vital to our experience. We always exist in the now: it is what separates the known past from the unknown future, generating memories and producing our experience. This now is what we shall refer to as the subjective aspect of time, formed by our lived experience and what we perceive–a perspective with a long history in skepticism, philosophy of mind, and religion. Such philosophical bavardage is starkly contrasted with the physical endeavor of defining the objective aspect of time, removed from our subjective intuitions, representing and predicting physical reality.

However, the physical description must not dismiss the subjective account, but rather explain our experiences. Thus, we must also explain why we experience time as always moving forward, away from the past, and towards the future[1]. Take a moment and reflect

[1] Temporal flow in and of itself is plagued with anthropic notions, which set human experiences as funda-

about why you believe time flows. One reason is that you are reading this very sentence, over the course of multiple seconds. It took time for you to read that sentence. Do you remember what you just read? Do you remember what you are about to read? It seems so obvious that there must be time flow from a known past to an unknown future. It is worth noting Aristotle's notion of actualizing potentialities[2] as being a method to understand the shift from the past to the future through the present. How can this be represented in more concrete terms useful to a physical description of the universe[3]? We often think of our experience of time as a point moving across a line, gathering new information rolling down the hill of time, away from the past and into the future. As humans, we are bound to such a perception of time, by particular features of our lived reality conflicting with our physical descriptions, namely time flowing unidirectionally–everyone experiencing time differently when in different emotional states, and everyone experiences time the same way. We will be focusing on the objective aspect of time, think of ourselves as not distinct from nature but a part of it, by reducing our minds simply to members of the thermodynamic system like any other[4].

Our search for a definition of time is plagued with the question, what would an objective and universal time look like? In this paper, I will investigate a definition of time using a non-traditional definition of information that can account for universal informational asymmetry and thus, universal temporal asymmetry. Even if there is no universal present, nor universal direction of time, one can never escape one's present moment. One can move to a different section of the universe where time flows differently but even then, one's present is always

mental in explaining non-human features of reality.

[2]Ackrill "A New Aristotle Reader" 1989, 1.5-9

[3]This itself can be the subject of its own paper, focusing on time in Aristotle. This is in fact what launched my interest in the philosophy of time, but I quickly became engulfed in contemporary literature. I hope to incorporate this into further work, doing justice by the conversation

[4]Maybe time flowing positively is necessary for human experience as we know it because we need memories of the past and wonders of the future to think coherently. The alternative is that we remember the future and make predictions about the past, which makes it difficult to understand how this method of thought is possible for us. It is statistically likely that the time flow of our section of the universe is an anomaly, and that time likely does not flow like this elsewhere but the fact that it is likely essential for our thought process makes it difficult to think about time's nature independent from our local experience.

where one is. This subjective notion of time aids our search for a complete definition of time as the subjective aspect of physical phenomena must be accounted for if our definition is to have a wide berth. "A view or form of thought is more objective than another if it relies on the specifics of the individual's makeup and position in the world, or on the character or the type of creature he is"[5]. From Aristotle to Brouwer, to Boltzmann, to Einstein, to Reichenbach, the relation between time and change takes deep roots in metaphysical commitments and physical descriptions as well as philosophical investigation.

Reichenbach argues that we are unable to define a temporal flow for the entire universe because he defines the asymmetry of time locally in a way that cannot be generalized to the entire universe. To do so, he relies on his argument for the branch structure of the universe. He argues that the way in which devices record traces statistically determined to have been left by causal interactions is the way by which we determine temporally asymmetric processes. I will demonstrate implications of using Reichenbach's model with the new definition of information, positing how information about states of information can be used in his model[6].

Such a view of the universe would require an atemporal perspective, an all-seeing point of view. This perspective is known as the Archimedean point from nowhen[7]. The atemporal point of view has instantaneous cross-sections in total symmetric order. I will take the perspective of Gabriel, an atemporal being living in Archimedean Point, observing the universe from an "untainted point of view"[8]. From this, in Section 4, I will produce a definition of time that accounts for the local physical description of time, and most pivotal, that we can have a universal time, from the ultimate vantage point. We will take Gabriel, an angel sitting on the point from nowhen as he observes reality from the Archimedean standpoint, decoupling our understanding of time from the view from within time.

In this paper, I shall motivate the traditional account of time and its relation to in-

[5]Nagel, "The View from Nowhere" 1989, p.5

[6]Reichenbach's method is purified, meaning, he does not explicitly consider factors like particle horizons or the expansion of the universe.

[7]Nagel 1989

[8]Price, "Time's Arrow and Archimedes' Point" 1996, p.4

formation, then we are going to add a new definition of information. The structure is as follows:

1. Present an account of time in physics from Newton through Einstein to Reichenbach, focusing on the traditional probabilistic account of time in probability thermodynamics and entropy's traditional relationship to information.

2. Discuss Reichenbach's registering devices, their utility in defining time order and direction in probabilistic terms, and the tradition of entropy's relation to information.

3. Propose a fictitious experiment, motivating Reichenbach's thesis that there cannot be a universal time direction supported by the General Theory of Relativity and propose a non-traditional account of information.

4. Critique Reichenbach's thesis by employing the non-traditional account of information in a registering device on a cosmological scale, accounting for relativistic problems of doing so from Archimedes point.

5. Argue that cosmological time can be defined in terms of non-traditional information size from which we can provide a definition of time.

The main argument I am making is that Reichenbach's account of time can in fact be used to give an account of what it would take to have a universal clock which provides an additional description to his thesis and the GTR. My critique is twofold: A) the traditional notion of information is insufficient and B) a new non-traditional ordering of information orients a universal time[9]. We must ask ourselves: What do we need in order to say that

[9] What it would mean to have a mental state that works by having memories disappearing with is something we are not familiar with in this paper but see Husserl's "Phenomenology of time-consciousness" for a discussion. In the sense that time-consciousness is akin to moving along a number line, we can make sense of consciousness in opposite time. However, it is less clear what it would be like to experience thought in opposite time. Reichenbach thinks that it would be the same process as moving left as opposed to right. This discussion must proceed in a different paper, but holds great significance to the exploration of human experience.

there is a universal orientability of time? Is this achievable? Thus, “what would it be for the world to come equipped with a time orientation?”[10]

2 Time in Physics

Newtonian physics and theory of relativity are used to explain physical phenomena with great accuracy and explanatory power. Einstein’s Special Relativity is even able to predict and explain that time’s rate is relative to the observer’s frame of reference. However, these theories, along with nearly all other physical theories, are time reversal variant, meaning they apply symmetrically backwards and forwards in time for causally connected events. Events need to be causally connected for their events to be reversed as implied by the Lorentz transformation and Einstein’s Relativity. It seems that time flows ‘normally’ by chance or by brute fact since our symmetrical laws cannot account for its apparent asymmetry. However, our subjective experience of time seems inconsistent with such a symmetric description of time; we experience time as asymmetric flowing in one direction from a fixed/determined past to an unknown future.

Newtonian physics treats time as an absolute backdrop against which events unfold uniformly, independent of the observer. In stark contrast, Einstein’s theory of relativity introduces the concept of spacetime, where time is intertwined with the spatial dimensions and varies relative to the observer’s motion. This revolutionary idea not only challenged the absolute nature of time but also introduced the concept that time’s flow could differ based on gravitational fields and relative speeds. Discussing these foundational theories in juxtaposition highlights the evolving understanding of time from a fixed entity to a dynamic, observer-dependent dimension.

Furthering observer dependence, we remember the past and not the future, we can change the future, and not the past, and we seem to only live in the present. Reichenbach outlines 6 qualitative properties of time:

[10] Earman, “An Attempt to Add a Little Direction to the Problem of The Direction of Time” 1974, p.19

1. Time goes from past to future;

2. The present, which divides the past from the future, is now;

3. The past never comes back;

4. We cannot change the past, but we can change the future;

5. We can have records of the past, but not the future;

6. The past is determined; the future is undetermined;

These aspects of temporal asymmetry are not captured by most macro-physical descriptions of reality, except one–thermodynamics[11][12].

In thermodynamics, time is reduced to entropy's increase, as described by Boltzmann (1896) and Reichenbach (1972). The statistical model of entropy in statistical mechanics and thermodynamics was developed by Boltzmann and represented by the formula $S = klogW$ (S: entropy; k: Boltzmann's constant; W: number of microstates). The second law of thermodynamics makes it possible to express mathematically the direction controlling the course of physical occurrences[13] that involve heat transfers. Think of a box of ice left out at a barbeque. As time passes, the ice melts and the box gets warmer until the water is "room temperature". This is an irreversible process of heat transfer since, in the same conditions, the box of ice will not re-solidify into ice. In statistical terms, the box warms up because arrangements of particles go from less likely arrangements to more likely arrangements because the ice requires a very specific setting that is less likely than the more general and thus more likely settings for liquid water until equilibrium is reached. A system is in equilibrium, which is a macrostate description, when its constituent microstates are shuffled as chaotically as possible.

[11]Reichenbach "The Direction of Time" 1956, p.20-23
[12]Quantum theory also accounts for temporal asymmetry, but on a micro level
[13]Reichenbach 1956, p.49

Briefly, macrostates are the aggregate of the arranged microstates, corresponding to the large-scale state of the particles. Microstates contain all of the information of the individual particles constituting the given macrostate, the items in the macrostates where the macrostate is the set of microstates. Microstates are the individual arrangements of particles which make up macrostates, which are the big picture microstates[14]. Consider footprints in the sand. When discussing the microstates, we see the footprint under a microscope where we can identify some peaks and valleys, but we do not get much about the big picture. The macrostate is the entirety of the microstates, that we can see as the footprint as a whole (the macrostates should also be a set of microstates)[15]. Just as a deck of cards as a set is made up of 52 single cards arranged in a stack, a macrostate is made up of many microstates arranged and defined as a set[16]. These macro and micro states have relative arrangements, probabilities, and entropies. Moreover, the macromechanisms show us the statistical properties of micromechanisms. Moreover, each microstate provides the full description of every particle individually in the gas at a singular point in phase space. When a macrostate is said to be a state of high entropy, this means that the macrostate is realizable by a high number or possible organizations of microstates. When the entropy of a system is stable and the microstates are evenly distributed, the system is said to be at thermodynamic equilibrium. Conversely, a macrostate is said to be a state of low entropy when there is a very low number of microstate arrangements that satisfy the macrostate. The significant fact to take away is that entropy is described as the tendency of particles in phase space, in a closed system, to progress from less probable to more probable macrostates.

We can think of this as low entropy macrostates having a very low probability of existing because the conditions necessary for their existence are very restrictive and unlikely. We can think of a deck of cards arranged perfectly by color: such an arrangement is ordered, and unlikely. Likewise, high entropy macrostates have a high probability of existing because the

[14] Boltzmann "Lectures in Gas Theory" 1896, p.451
[15] Boltzmann 1896, p.451
[16] Just as $\mathbb{R}$ is made up of the set of natural numbers

conditions for their existence are much less restrictive than lower entropy ones, and therefore likely. Thus, assuming states begin in a state of low entropy, from $S_a > S_b$, one can in practice infer that the larger entropy state proceeds the smaller one, thus providing an asymmetric direction of entropic progression, which entails an asymmetric progression of time[17]. When a gas is hot, typically it is in a state of low entropy, meaning the particles of the gas are unevenly distributed (bunched up tightly) whereas when a gas is cold, generally it is in a state of high entropy, such that the particles are more evenly distributed throughout the space. In a closed system, a gas tends to progress from hotter to colder states.

There is also an important connection in the tradition between entropy and information. The more structured a system is, the more specification as to its specific shape and ordering as opposed to a random arangment, requiring little information.[18] Thus, when a system loses structure, it loses information. From this we get the relationship of $\Delta S = -\Delta H$ and conversely, $-\Delta S = \Delta H$ (where S is entropy and H is information). I will call this the traditional notion of information or internal information since it is directly present in the system. From the equation defined from entropy above, we get $\Delta I = klog(p_0/p) = -klogp + W$, where p_0 is our number of possible outcomes and p is a specific choice. From this we derive the negentropy principle of information which states that a gain of information must be accompanied by an increase in the entropy of the system such that $\Delta S \geq \Delta I$[19]. Boltzmann and the traditionalists understand entropy to be negative information. When $\Delta S = 0$, $\Delta H = 0$ as well. In this tradition, if $\Delta S = 0$ and $\Delta H = 0$, then there is said to be no time–the ledger of space-time is blank. Therefore, time is reduced to entropy's increase such that $\Delta S = 0$ is temporally undefined.

The advantage of entropy as a descriptor is its possible application to non-thermodynamic systems[20]. Such a probabilistic account in physics provides a structure for what constitutes a time-directed physics: higher entropy states are much more likely to follow low entropy

[17] Reichenbach 1956, p.117
[18] Davies "The Physics of Time Asymmetry" 1974, p.52
[19] Davies 1974, p.53
[20] Davies 1974, p.52

states. Generally, when a gas is introduced into a container, assuming its initial state is of low entropy, the gas will expand, becoming more disordered within the container. This expansion is represented by gas moving from a more ordered, less probable state to a more probable, less ordered state. Ludwig Boltzmann claims that this process is due to the fact that macrostates with high entropy are more likely distributions for the constituent microstates, so they progress from low entropy states with low probabilities of being realized to high entropy states with high probabilities of being realized[21]. Thus, for Boltzmann's reduction of time to entropy to work, we must assume a low entropy initial condition, hereby referred to as the initial boundary condition. Given the asymmetric nature of entropic progression, I will reduce time and temporal direction to entropy.

It is important to note that these laws and principles are not absolute in nature, they are probabilistic, meaning they strongly tend to be asymmetric but are possibly symmetric, albeit unlikely. The thermodynamic account of entropy provides us with a physical theory that is in expectation asymmetric, which is closer to an explanation of the asymmetry we experience and perceive.

The probabilistic description of time becomes particularly significant when considering the behavior of subatomic particles. Experiments such as those involving the decay of radioactive isotopes demonstrate that while we can predict the probability of decay over time, the exact moment when a specific atom will decay cannot be predetermined. This unpredictability reinforces the probabilistic foundations of temporal physics, challenging the notion of a universally consistent flow of time and underscoring the need for a more nuanced, statistically driven understanding.

The probability-driven asymmetry of macrostates tending to increase in entropy provides a physical description of a system that is time reversal invariant, meaning it is not the same when played backward than when it is played forwards. Some additional principles to strengthen this claim are:

[21] Boltzmann 1896, p. 447

1. Clausius' principle- no cyclic transfer whose sole thermal consequence is the transfer of a given quantity of heat from a cooler body to a hotter body is possible.

2. Kelvin's law- a transformation whose sole final thermal effect is to transform into mechanical energy heat extracted from a source which is at the same temperature throughout is impossible.

In conjunction with these principles, time's strong connection to motion emerges through the Lorentz transformation where "Reversal of time merely reverses the direction of motion"[22] with respect to a fixed reference frame. "Space and time are not absolute; that length, time, and mass depend on the relative motion of the observer; and that the speed of light in a vacuum is constant and independent"[23]. Further, how we describe motion is in terms of causality, where causal chains represent empirical facts that cannot be reduced to logical necessity[24]. Such events are partially ordered, meaning their ordering is symmetrical, transitive, and reflexive[25] So, we can reduce time to ordered states that are causally related, but this process does not account for the direction of causality, only that events that are causally ordered are thus temporally ordered accordingly. 'If A lies at the beginning of the chain and B at the end, A is called earlier than B, and B is called later than A."[26]

Causality, in cosmology, functions differently than one might think. If events are separated by too much space, it is nonsensical to speak of them as being in causal relation to one another because of three main factors: particle horizons, wave horizons, and light cones. For now, we can focus on the latter most of these. A light cone is a model that represents all possible directions and speeds that light can travel from a given event "since light is the fastest causal chain of all"[27]. The concept of causality in relativity states that an effect cannot occur before its cause, and the maximum speed at which any signal or information can

[22] Reichenbach 1956, p.42
[23] Britannica, 2024
[24] Reichenbach 1956, p.37
[25] Reichenbach 1956, p.38
[26] Reichenbach 1956, p.39
[27] Reichenbach 1956, p.40

travel is the speed of light[28].[29] Since nothing can travel faster than light, any causal influence (like information or a physical effect) must propagate within the bounds set by light cones. If two events are outside each other's light cones, they are said to be "spacelike separated"[30]. This means there is no way for light (or any faster-than-light influence, which is forbidden) to travel between them within the time interval separating the events. As such, one event cannot possibly affect or be affected by the other causally. The relativity of simultaneity further complicates things.

In different frames of reference (moving relative to each other), the order in which events occur can appear different unless they are causally connected (i.e., within the same light cone). This reinforces the idea that causality can only operate within light cones. Thus, events that are separated by distances so far apart that light from one does not reach the other, they have no interaction with one another and thus cannot be causally connected to one another because they are not connected by any information. Furthermore, such events are said to be relatively simultaneous since they both lie at some point between moments relative to one another, but we cannot attribute an exact moment. Thus, such events are considered to be indeterminate in their causal and temporal relation.[31]

If we have a simplified universe with two separate light cones that are so far apart in the expanding universe that they will not ever interact, then it is impossible to say if any one event happens in one at the same time as another. The creatures in the first light cone would never interact with those in the other and vice versa. So, they have no causal connection with one another and given the relativist nature of the universe, there is no real way to define one moment of simultaneity between events over any other and then no internal information is exchanged between the two. It is helpful to think about simultaneity as Poincare puts

[28]Einstein, 1905

[29]Huw Price in "Backwards Causation and the Direction of Causal Processes: Reply to Dowe", and Jan Faye in "Backwards Causation", among others, argue for the possibility of causation in both directions. So, the claim about cause preceding its effect is something we are taking for granted in our discussion but is very much a debated topic in both physics and philosophy

[30]Davies 1974, p.95

[31]Reichenbach also defines this as simultaneity on page 39

it: "Simultaneity is a convention, nothing more than the coordination of clocks by a crossed exchange of electromagnetic signals taking into account the transit time of the signal [...] not a truth."[32] Thus, these considerations inform us that there is no universal time; time is defined locally, driven by probabilistic laws.[33]

3 Registering Devices: How to Tell Time

There is strong reason to believe that the human mind experiences time similar to a video camera, in successive frames of events past, lens open towards the future. We can replay our memories as we scroll through our mental records of lived events where "records are ordered macroarangments the order of which is preserved; they are frozen in order so to speak"[34]. This must be taken with reservation as there is research in psychology describing that memory does not function as a camera. [35] However, for the sake of this conversation, we are going to assume the basic function of a human mind (in our normal time) takes in stimuli, commits it to memory, and does not forget the past and remember the future such that "minds are constituted as any other electrodynamical system[36]. Hans Reichenbach in The Direction of Time likens minds to registering devices, defining an order and a direction of objective and subjective time. A feature of temporal progression is markings made by past events that persist in the subsequent temporal segments, such as memory– both in minds and in recording devices as an increase in recorded internal information. Reichenbach claims that these registering devices indicate the progression of a low entropy state to a higher entropy state and that such devices are akin to memory in their ability to explain how we experience the past to the future correlating to mind-independent physics.[37]

In his book "The Direction of Time" (1984), Hans Reichenbach defends Boltzmann,

[32]Galison "Einstein's Clocks, Poincare's Maps" 2003, p.36

[33]As it stands now, our physical laws do not explain the low initial entropy state of the universe, so we take it as an extra theoretical assumption. Thus, it seems that entropy alone cannot explain temporal asymmetry

[34]Reichenbach 1956, p.151

[35]Include sources here

[36]Price "The Flow of Time" 2009, p.19

[37]However, there are aspects of memory and registering devices that are dissimilar in key ways.

arguing for the thermo-statistical definition of time, meaning time is reduced to the increase of the chaos of a system, driven by probability instead of deterministic laws. However, Reichenbach thinks that entropy itself is insufficient for establishing a direction of time, but requires the addition of the principle of a common cause: If coincidences of two events are A and B occur more frequently than would correspond to their independent occurrence, that is, if events satisfy relation $P(A.B) > P(A).P(B)$, then there exists a common cause C for these events such that the fork ACB is conjunctive[38]. His argument relies on "registering devices" a term he uses to conceptualize tools or mechanisms—similar to how seismographs capture the Earth's movements—documenting the order and direction of macro-information by their production of ordered marks. A mark is the result of an intervention by means of an irreversible process[39] that lasts after the event is completed, recording cause and effect relationships. This means that they are preserved for a prolonged duration of time serving as records of the past because they have within them information about their cause and causal explanations, i.e. footprints in the sand are records of a person stepping in the sand creating order amongst the chaos of random scattered sand particles. Registering devices produce traces of internal information (H) in accordance with the traditional definition.

These devices are essential in understanding how events unfold in "normal time" and "opposite time." We can think of opposite and normal time as two possible mutually exclusive worlds. Normal time and opposite time are described in terms of probabilities. If there were a small, isolated corner of our universe where entropy was decreasing, and if we were to look through a telescope at the opposite time section of our universe, assuming things work the same as they do with us, we would see every causal event we know happening in the opposite direction. In opposite time, we can thus have no record of events since records are post-interaction. The records precede the events, thus providing an account of finality instead of by causality. Finality, in the vocabulary of opposite time, is when the statistics are reversed such that we observe the marks before causes occur in the same way when watching

[38]Reichenbach 1956, p.162-163

[39]Reichenbach 1956, p.198

a movie in reverse, we see the resolution before the character introduction. If there were no common cause C, the common effect would establish a statistical dependence between events, whose explanation would be given in terms of "final cause" [...] which is regarded as incompatible with the second law of thermodynamics"[40].

This is just what opposite time is like. For us, an egg falling off of the counter and breaking is normal, but for the creatures in opposite time, an egg flying off the floor back onto the counter is normal. To them, the person is walking backward in the sand, their footsteps disappearing with every step, creating chaos instead of order. The flying back up and repairing of the egg does not produce a record or a mark, thus described in terms of finality instead of by causality; from ordered states to chaotic ones where type events eliminate token events of that kind. This is opposed to "normal time" where what happened in the past, the falling of the egg, is registered by the broken egg on the floor. This description of temporal progression with the egg also represents the state of entropy increasing for the egg falling and entropy decreasing as the egg rises, this is evidence for the reduction of time to entropy as an explanation for our experienced and measured asymmetry in the traditional account[41].

This statistical account of time as entropy's increase further confirms how the past precedes the future, insofar as the past can be recorded but the future cannot[42]. The present is the point at which the future is produced, the information of the past is unchangeable. That which causes the mark likely precedes the mark in temporal direction. However, in opposite time, the mark precedes the cause. Under the probabilistic account of causation, both descriptions, in positive and negative time, account for the marks in probabilistic terms.

[40] Reichenbach 1956, p.162

[41] Boltzmann is skeptical about conscious beings existing in world of opposite time with decreasing entropy. But Reichenbach argues that the sense in which they are opposite is not relative to some absolute thing but in relations to one another. In opposite time, Boltzmann is unsure how a mind would function. Reichenbach rethinks this. In both time and opposite time, one experiences time as positive since, in each, the traces that are left in each successive state then following the probability argument in later in this section, $P(A, B) > P(A)$ given causal relevance. Thus, both in opposite and positive entropic states time is positively measured given that time is a factor of a system's progress towards equilibrium, that exists in both positive and opposite time.

[42] Reichenbach 1956, 177

Thus, what is recorded is the past and what is unrecorded is the future while the present is the generation of the records as the future becomes a happening or in other words, produces the present; causes produce effects and effects are the products, and thus serve as records of causes. The set of events generated in the present are called ordered events.

Reichenbach is concerned with the ability to describe probabilistically events as accounting for the order of time as effects emerging from causes. For example, A and B, two apparently random events, emerging from a common cause C are explained by the single event C that brought them both about. To establish a common cause, coincidences of two events A and B must occur more frequently than would correspond to their independent occurrences. Reichenbach adds that the macrostatistics, providing order, are ordered because an external system interacted with that system, instilling the order serving as a record of the interaction[43]. This interaction is understood as the cause of the order. The slow change in these microarangments can be used to infer a length of time that has passed since the interaction. He says, "The memory of elements consists in a specific arrangement of elements which are too highly ordered to be interpreted as a product of chance"[44]. $P(A.B) > P(A).P(B)$, tying the causal arrow of time to the temporal perspective of observers and agents.

Consider the concept of causal forks within the framework of thermodynamics, where the initial conditions of a system can lead to multiple potential macrostates, each with its own probability. This phenomenon becomes particularly evident in systems approaching critical points, such as the phase transitions of water. For instance, at the critical temperature, water can either remain in a liquid state or begin to vaporize, and minor fluctuations in energy input can tip the balance in one direction or the other. This not only challenges the classical deterministic view of time but also underscores the inherent probabilistic nature of temporal progression in macroscopic physics. By examining scenarios where multiple futures stem from a singular thermodynamic state, we can better understand the implications of causal forks on the concept of time. Such cases illustrate probabilistic entropy and temporal

[43]Reichenbach 1956, p.179
[44]Reichenbach 1956, 179

direction.

Reichenbach also defends time's reduction to the increase of entropy by these statistical arguments, given their ability to account for internal information, the explanation of the sequenced events, and their predictive power. From this, we can describe cause as probability. For events that are causally unrelated, we cannot ascribe a temporal order because temporal order on this account is defined here as two events in lineal order. So, two events in non-lineal order cannot be said to be simultaneous, before, or after one another but only by approximation. Strictly speaking, they cannot be put in temporal order with one another.

For events that are in temporal order, the statistics dictate that entropy will continue to increase with slight fluctuations where a long downgrade in the entropy curve is permitted but highly unlikely. This means that time usually flows in accordance with "normal" or "positive" time, but can, in very rare instances, flow backwards, to a more ordered state. Moreover, Reichenbach understands these statistical progressions to underpin causality, thus giving a mathematical account of causal chains, defining the direction of connected events[45]. Each act of registering represents a system of total information in terms of the number of successive individual recordings and H; $H_n = n.H$. Thus, the time direction of information is the direction imprinted by statistical isotropy[46], recorded by the registering devices, in terms of macrostatistics. The witnesses for these causal chains, he says, are minds that he generalizes to registering devices identifying the progression between different entropic states with a common origin.

The choice of defining time in terms of "the ordering of successive states of entropy"[47] is useful to explain the direction of time, namely why time appears asymmetric while its underlying laws are reversible. Reichenbach argues that entropy's decrease is statistically improbable and defines the successive entropic states as causally related. We can, however, imagine scenarios with "opposite time". As opposed to "normal time", opposite time occurs

[45] Reichenbach 1965, p.177
[46] Reichenbach 1956 p.183, Davies 1974 p.18
[47] Reichenbach 1956, p.114

when entropy is decreasing, identified by registering devices, in effect, erasing their records. Imagine a seismograph recording the vibrations of the earth. In normal time, the earth shakes, and the device generates a record of the event. In opposite time, the device erases its record right before the earth vibrates, the earth only coincidentally moving in accordance with the pen[48]. Cases like this, he argues, show that registering devices can only record the past, not the future because in the cases of opposite time, the devices did not possess information explaining the future[49].

Ordered events are not isolated from one another in isolated systems, but from each interaction of ensembles an individual item is produced. The flow of time is thus explained by the direction of events which have the most explicative power in their statistical significance such that the likelihood of the next event happening increases, which is understood as progressing from a cause to an effect. The statistical relations are less significant when progressing from effects to causes (in the narrow sense of the terms) than they are from causes to effects. In short, that which has the most predictive power, insofar as it expresses the highest probability of the next event in order, produces the directionality of time.

A crucial point in his argument is that such accounts must be causally related, as understood through Einstein's Relativity. Such events that are within each other's light cones are covered by his description and can be put in temporal juxtaposition with one another. However, events that are not within each other's light cones cannot be said to be simultaneous, before, or after one another since they are not causally connected. This creates a worldline[50] for an observer who we will call Gabriel, an angel with a view from Archimedes' point. When such light cones do not intersect, there cannot be said to be a universal time and thus, the idea of a universal cross section is difficult to conceptualize on the traditional

[48] Reichenbach 1956, p.184

[49] This passage can also be interpreted in the following way. Opposite time is simply defined as the reversing of causal structure, and causal forks. In this interpretation, the beings in opposite time identify the causal process as operating backwards while maintaining the same explicative power. Therefore, instead of having C to A and C to B, we would have A to C and B to C, simply reversing the direction of the arrows. For the purposes of this paper, we will acknowledge the possible disagreement and proceed.

[50] Otherwise known as a causal chain.

account because it lacks simultaneity. However, this may be usurped by Gabriel's view from the edge of the universe, being removed from the system as a disembodied soul.

What is most important to remember is that time is a progression of macrostates of entropy, and entropy tends to increase, thus time tends to increase. There is the possibility that entropy decreases but it is very very rare but statistically inevitable. Nonetheless, the asymmetry we perceive is statistical in character. The imprints made on the registering devices are akin to the imprints made by memory in our minds. Thus, as registering devices, we perceive time as memories of past presents and anticipations of untold futures through the generative present. Such macrostates progress in accordance with probability theory in this marking process such that marks are representative of different causal chains. Such causal chains are derived from probability chains, describing the evolution of the universe[51]. From this, marked events are much more likely to proceed unmarked ones, such that marks are in the short term constructive, in the order which is the most likely, screening off events which are causally relevant. We have a definition of temporal orientation in the following sense:

1. DEF For events A_i, A_k, A_l such that $l > k > i$.
2. DEF For events A'_i, A'_k, for the event resulting when a mark is added to A_i, A_k.
3. DEF A^1_i, A^1_k are events within the same causal net as A_i, A_k who individually do not screen off the latter but in conjunction they do.
4. If a mark made in an event A_i shows in an event A_k, then A_i is causally relevant to A_k
5. Then $P(A_i, A_k) > P(A_k)$.
6. Also, either $P(A'_i, A'_k) = P(A_i, A_k)$ or $P(A'_i, A_k) = P(A_i, A_k)$.
7. If A_2 screens off A_1, and of a mark made in A_1 shows in A_2, then it also shows in A_2.

[51] Reichenbach 1956, p.95

8. If a set A_i^1... A_i^n screens off A_i from A_l and if a mark made in A^i, shows in at least one of the events A_k^1 ... A_k^n.

9. Thus, An event A_i is causally relevant to a later event A_l if $P(A_i, A_l) > P(A_l)$[52].

10. Through the screening off of marks, we can establish temporal asymmetry by causal relevance.

4 Local but No Universal Time? A Fictitious Experiment

I will show through a thought experiment that from a universal perspective, we in fact can have a universal definition of time, across causally separate events and distinct lattices, from the perspective of an atemporal point on the boundary of the universe. If we can accept the point from nowhen as a perspective, then we can define a universal time.

I will propose a new relation between entropy and information by proposing a second kind of information, external information, that accounts for temporal asymmetry. The goal of this thought experiment is to argue for a new relation between entropy and information against Boltzmann and Reichenbach's theory of time.

Here is how we will proceed for the remainder of the paper:

1. We will present a thought experiment in a "quasi isolated system"[53] in Laboratory Thermodynamics where Gabriel is an ideal observer, an angel who lives in the Archimedean point from nowhen- Two Boxes, No Time.

2. We will generalize the Laboratory universe to a cosmological scale and argue that there can be a description of universal time from Gabriel's privileged vantage point.

[52]Reichenbach 1956, p.201-2

[53]Davies 1974, p.80

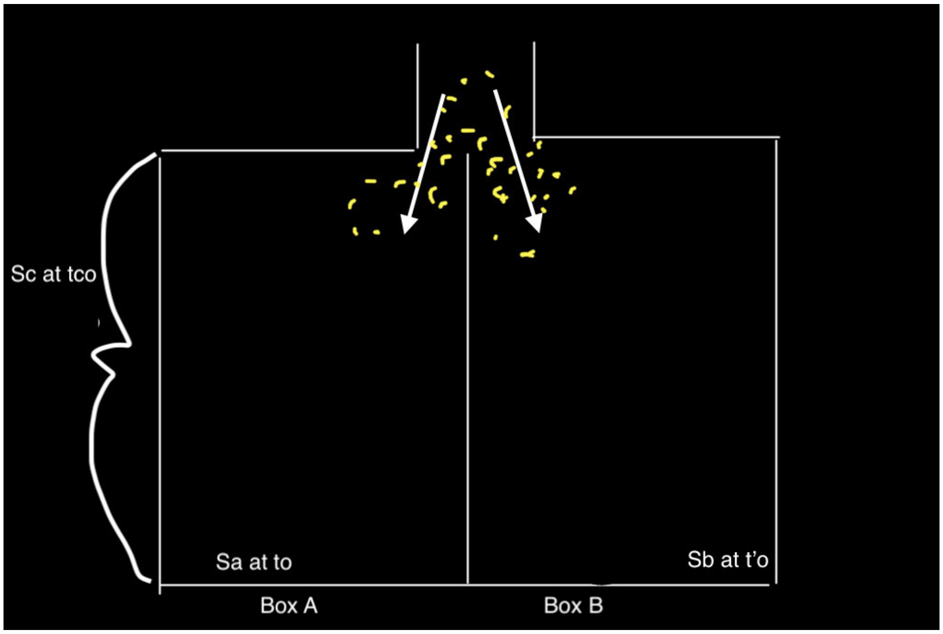

Figure 1: Box A and Box B are filled with the same amount of gas from the same origin

4.1 Two Boxes, No Time- A Laboratory Experiment

Let us perform a fictitious experiment. We will show a scenario wherein there is no temporal progression in a well-defined universe where the sum of the change in entropy is null. Now imagine we have two boxes, one next to the other insofar as they share a wall. Assume the boxes are thermodynamically separate from one another. A pipe is attached to the boxes directly at the midsection between them, filling them both up with an even amount of the same gas such that both boxes have the same type and quantity of gas forming one macrostate (Fig. 1). Then, the line is sealed and both boxes are thermodynamically separate from one another. Thus, we can represent the graph of these two boxes and the external world as follows in Figure 2.

Now we define the universe to be these two isolated boxes containing gas with the same origin[54] such that Box A and B make up the whole universe.[55] Let us imagine that the box

[54] As per my conversations with Professor Davey, both gases having the same origin is not essential for this experiment. Rather, I wish to remain consistent with Reichenbach's branch model of the universe, for which further writings on this paper will be produced.

[55] There is a small caveat here. For this experiment to function properly, the gas in B must begin at an initial state of high probability to then progress towards a state of low probability, which we are understanding here as progressing from the initial state of relatively high entropy with respect to its final state.

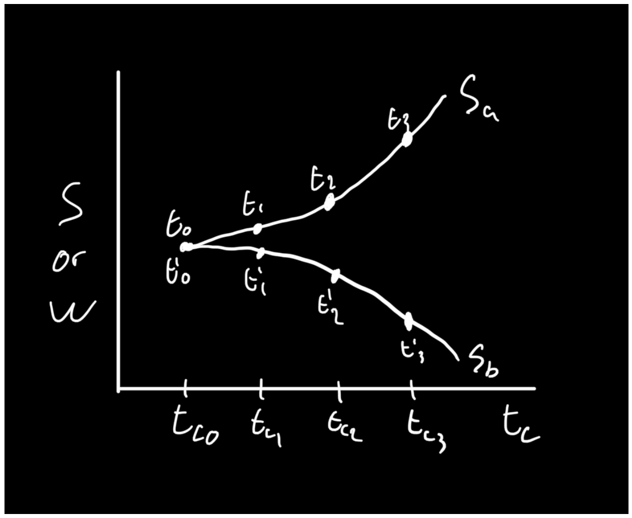

Figure 2: Graph of the relative times of the entropies of box A, box B, and the overall universe

on the left, box A, has an entropy S_a of system T_a, where T_a is the type system of which the entropy is a token, such that S_a is increasing. Now imagine that the box on the right, box B, with entropy S_b of system T_b, where T_b is the type system of which the entropy is a token such that S_b is decreasing[56]. In figure three, we see that T_a and T_b originate from one state interaction C of interaction that they branch off from the same causal root[57]. Box B represents a statistical anomaly under Boltzmann's statistical account to entropy, but for the sake of the experiment we are exploiting the possibility. The reason these boxes are thermodynamically isolated from one another is that Boltzmann argues that worlds with decreasing entropies are separated from those with increasing entropies by great spatial distances, accounted for here by the wall so that we may describe the whole universe as these two boxes consistently.

We are told that "small isolated regions of the universe will always find themselves 'initially' in an improbable state"[59] by the H theorem. So, we can say that in box A at t_0, we observe a state of low entropy. The same applies for t'_0 in box B. For the sake of the

[56] "There will however in fact occur processes going in the opposite direction"(Boltzmann 1896, p.447)
[57] Reichenbach 1956, p.127
[59] Boltzmann 1896 p.447

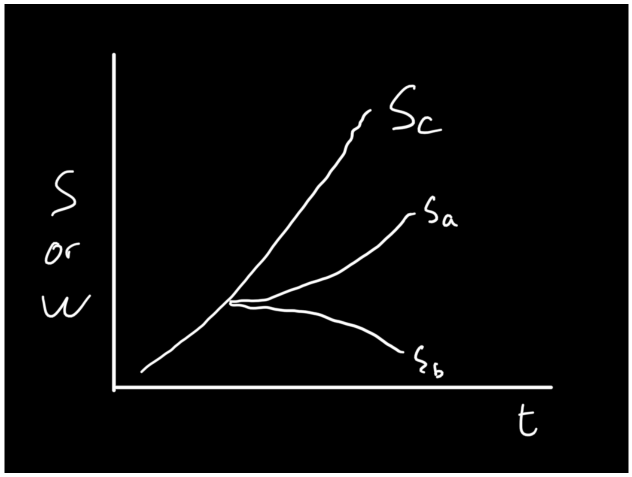

Figure 3: "The initial upgrade of the entropy curve of the universe branching into isolated systems"

58

experiment, let us assume S_a and S_b are equal to one another in their initial states[60]. So, from the universal perspective, since the entropy of a large system is comprised of smaller systems, the larger state's entropy is equal to the sum of the smaller state's entropy, we observe a low entropy state, S_c, of the universe, where the universe $boxC = boxA + boxB$. We can do this because since the universe is spatially finite, we can speak of its state at a certain time, which we call t_{c_1} for the state at t_1 and t'_1 (Fig. 2). Such a state is called an instantaneous [temporal] cross section through the four-dimensional space time world[61] for which we can define a value of entropy of the laboratory universe[62].

Also, entropies are additive such that $S = S1 + S2$ follows because probabilities are multiplicative; the logarithmic function of $S = klogW$ transforms the multiplication into an addition[63]. Thus, the entropy of the laboratory expirement universe as defined above is S_c= S_a+S_b. At t_{c_0} Gabriel would have the sum of S_a at t_0 and S_b at t'_0 (Fig. 1 and Fig. 3). It follows from the traditional relation between entropy and information that $H_c = H_a + H_b$.

[60]Alternatively, we could have assumed both gases be instantaneously placed into the containers, Box A with a low entropy initial state and box B with a high entropy initial state. This might have made the experiment clearer and more probable. However, this would not have changed the significant aspect of the experiment that box A and box B will have opposite entropies. Furthermore, this account maintains consistency with Reichenbach's model of entropy in *The Direction of Time* Chapter III Section 14.

[61]Reichenbach 1956, p.113

[62]Reichenbach 1956, p.54

[63]Reichenbach 1956, p.55

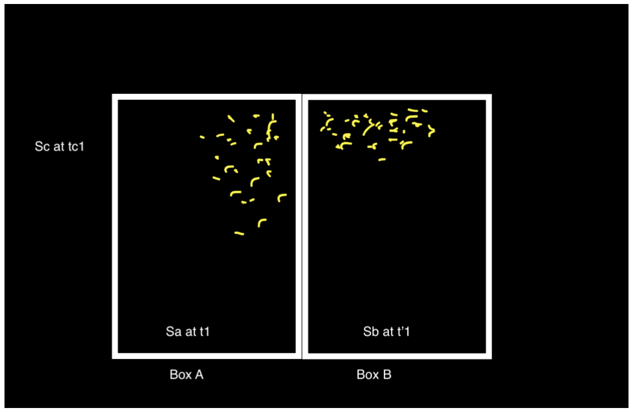

Figure 4: At t_{c_1}, S_A has increased while S_b has decreased

The angel Gabriel sits at the center of the universe, right in between the two boxes. He is at the informational center of the laboratory universe such that Gabriel is equidistant from each light cone and the light emanating from each box reaches him at the same instant. Gabriel's mental image can thus be represented by figures 4-6 as the succession of universal cross sections (hereby referred to as UCS). Gabriel, for the purposes of this thought experiment, is reducible to a camera, registering states of the universe at simultaneous universal cross sections by the generation of traces in his mind marked by Light, or Luminosity L.

What we are taking to be simultaneous between the events in box A and box B follows from $t_2 = t_1 + \epsilon(t_3 - t_1), 0 < \epsilon < 1$. But an important assumption we are making here is that Gabriel is able to see both boxes at exactly the same time. Thus, we can say they are simultaneous with respect to Gabriel's perspective and the ambiguity is dismissible given the small scale of the universe here.[64] Furthermore, this comparison is permitted as "in spontaneous juxtaposition, we regard a comparison of their time directions as possible"[65] in such a universal cross-section.

Now we observe the state of the laboratory universe at t_{c_1}. In Box A at t_1, he observes S_a increases as the gas expands in the container, fulfilling a more chaotic and even distribution throughout box A. In Box B at t'_1, he observes S_b decreasing as the gas in box A bunches up

[64]This will be important in the next section when we introduce the point from nowhen. This perspective differs because of its externality to the universe.
[65]Reichenbach 1956, p.35

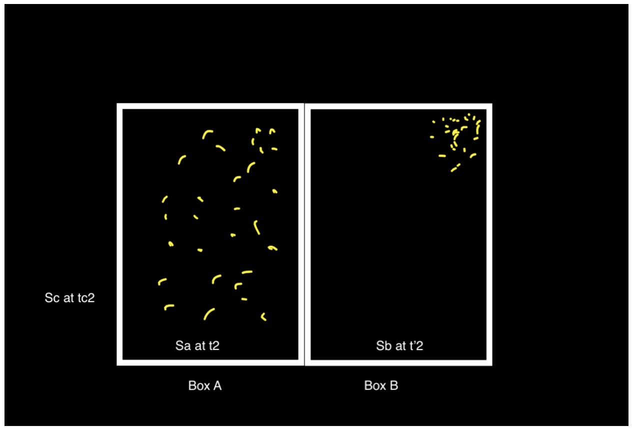

Figure 5: At t_{c_2}, S_a increases further while S_b decreases further

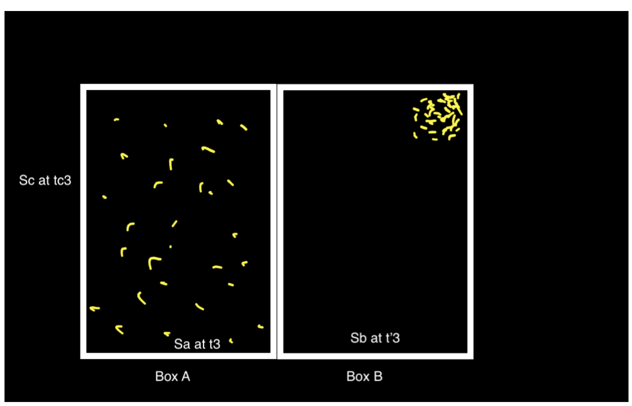

Figure 6: At t_{c_3}, S_a has increased further while S_b has decreased further

further in a corner of the box, fulfilling a more ordered and uneven distribution throughout box B (Fig. 4). We assume the increase of S_a happens with inverse proportionality relative to S_b. Thus, Gabriel identifies H_a as decreasing while H_b as increasing. He observes the continuation of this progression at t_{c_2} such that S_a at t_2 increases while S_b at t'_2 decreases (Fig. 5). Further at t_{c_3}, S_a at t_3 continues to increase while at t'_3, S_b continues to decrease (Fig. 6). He assumes the evolution of both gases continue in their respective ways until t_{c_n}[66]. At t_{c_n} , we would have S_c be the sum of S_a at t_n and S_b at t'_n. Assuming both gases are expanding and proportionally (with inverse relation), then their sum at t_n would be 0 such that $S_{c_{t_n}}$=($S_{a_{t1}}$+$S_{b_{t'_1}}$) + ($S_{a_{t2}}$ + $S_{b_{t'_2}}$) + ($S_{a_{t3}}$ + $S_{b_{t'_3}}$)... ($S_{a_{tn}}$+$S_{b_{t'_n}}$)=0. Thus[67] ΔS_{ctn}=0. Boltzmann and Reichenbach would conclude that since there is no overall entropy change in the system and thus no information change, there is no time in the universe.

For an observer inside of box A, time moves positively, but also for those in box B: "Observational probabilities will always [...] supply a direction of positive time."[68] and "The direction of most thermodynamical processes in an isolated system occur is the direction of time"[69]. For the observers in each box, time of progressing forward relative to their reference frames but opposite one another relative to each other from Gabriel's perspective because "it would forever remain unknown to the inhabitants of the second time section that their time direction was different from ours."[70]. However, on Boltzmann's account, the time for the entire system is null.

Reichenbach argues that "if we are on an increasing part of the curve, statistics accessible to us will always concern vertical axis of the lattice but if we are in a decreasing part of the curve, we will measure positive time as well"[71]. The specifics of the lattice are not significant

[66]We can make this assumption based Reichenbach's argument that in any given area of space whose entropy is not in equilibrium, S is either increasing or decreasing. As per the graph on page 111, the entropies tend to increase until equilibrium then, very infrequently, decrease before ultimately returning to equilibrium. However, these changes in direction of entropy are few and far between. So, it is reasonable to assume that until t_{c_n}, The entropies in the boxes will maintain their course.

[67]In fact, we observe this result at every state except the initial one.

[68]Reichenbach 1956, p.127

[69]Reichenbach 1956, p.127

[70]Reichenbach 1956, p.128

[71]Reichenbach 1956 p.127

right now. What is important, however, is that the statistics accessible to us, within a subsystem, are increasing if we are on an increasing part of the entropy curve and will also be increasing if we are on a decreasing part of the curve. This means the creatures in Box A will record time as moving forward (positive direction) and so will those in Box B. This account of time as entropy accounts for the asymmetry of time in experience.

Under Boltzmann and Reichenbach's understanding, Gabriel experiences no direction of time in the universe, given that he is reduced to a registering device. Since when $\Delta S = 0$ $\Delta H = 0$, Gabriel has a blank record for the UCS since there is nothing to record in traditional internal information. Despite there being time flow in box A and box B respectively, Gabriel records no universal time flow if we take positive time's direction to be defined as the direction of entropy's increase in the aforementioned account. Specifically, box A is experiencing positive time whereas box B is experiencing negative time since positive time is defined as the direction in which most thermodynamical processes in an isolated system occur[72].[73]. This traditional account is incomplete for one simple reason and I will explain why on the next page.

Furthermore, Boltzmann adds "For the universe, the two directions of time are indistinguishable, just as in space there is no up or down"[74]. What Boltzmann is saying here is that what gives the direction of time meaning to us is the same notion that gives direction meaning to us; relation to something fixed. What down means for a person standing on a planet is up for a person on a nearby planet, looking up at us. Thus, time has direction with respect to a specific subsystem. This provides an interpretation of the box experiment that accounts for a dead universe with temporal direction within its sub-systems. Thus, creatures in both boxes would define time as progressing forwardly as two pedestrians walking past each other are both walking forwardly relative to themselves, with opposite velocities relative to an external third person observer. $-S = +TL$ (left arrow) and $S = +tR$ (right arrow)

[72]Reichenbach 1956, p.127)
[73]This is acceptable because Reichenbach's model is highly idealized
[74]Boltzmann 1896, p.447

but, $-S \neq +TL$ and $-S \neq +TR$.

The external third person observer can identify that each person is moving opposite to one another. They do so by having UCS 1 where they are face to face, UCS 2 where they begin to pass one another, and UCS 3 where they have fully passed each other. Gabriel's record is of each stage of progression. The record as it exists in Gabriel's mind is distinct information from what is present in the boxes themselves. External information is information about internal information distinct from external information. "$\Delta H = +$" is one bit of information just as "$\Delta H = -$" is another bit. Thus, Box A and B produce two bits of information for Gabriel. Therefore, the traditional account fails to capture the asymmetric size of Gabriel's external information states when mapped onto the states of the boxes.

Throughout this example, we have been able to describe time flow in individual isolated subsystems. We concluded by presenting an apparent paradox that temporal flow can exist in a laboratory universe for which the summed time is equal to 0. However, Reichenbach would say that there is no such paradox since "Time direction can be defined only for sections of the total entropy curve"[75]. Thus, time and time's direction only have significance on sectional levels according to Reichenbach and can only be defined in sections of the overall universe. Thus, the total entropy curve does not change.

Nonetheless, Gabriel takes instantaneous cross sections of the entire laboratory universe; the entire entropy curve is represented in Gabriel's mind and thus, a time direction is identified as the total entropy curve when his static, atemporal record books are mapped. Figures 4-6 are universal cross sections stored in the camera that is Gabriel as information. Thus, the successive universal cross sections change while universal entropy remains constant[76]. Problems of this nature were identified by Reichenbach in that entropy alone cannot account for the flow of time but only in conjunction with the common cause principle and registering devices. However, the generation of traces, in Reichenbach's case, were tied to the direction of entropy. In this example, there is no universal entropy change but there is a record by the

[75] Reichenbach 1956, p.127
[76] As visible in the change in states from fig4-6

registering device of a succession of universal cross sections. The registering device of the laboratory universe, in its capturing of successive states of the universe, generates traces of the laboratory universe in Gabriel's mind.

There seems to be an issue here. If there is no overall entropy change, then there should not be a larger bit of external information, but there is. The successive states of events as registered by Gabriel in the laboratory universe constitute a partial ordering (that we will show when we generalize this to a cosmological scale is lineal). Thus, regardless of the entropy gradient in either section of the laboratory universe or the whole, and thus regardless of the information present, Gabriel will register an increase in information by virtue of taking a snapshot of successive states. Whether there is increase, decrease, or stagnation of ΔH [77], H_g in Gabriel's mind, is partially ordered such that each UCS has more information than its predecessor. Gabriel recorded each stage of progression and in so doing, has a record of not only the internal information but also the external information. $-\Delta H = \Delta S$ in the traditional sense, but information about information, external information, that being information about change, is a novel, non-traditional notion of information. The increase or decrease of internal information are themselves bits of information in Gabriel's mind.

Gabriel's disembodied viewpoint reveals something fundamental to us about the nature of information; information about information change is information apart. The traces in Gabriel's ledger of $-\Delta H$ it itself a bit of information in Gabriel's mind.

Thus, contrary to the traditional model, there is a second for of information- external information which is defined as H_g about H. Thus, $UCS_2[H_g^2] > UCS_1[H_g^1]$ such that $H_g^2 > H_g^1$ in Gabriel's mind. This deviation from the traditional model of information can give us a universal time, even in instances of $\Delta H = 0$. Gabriel's ledger can be constructed such that each UCS page of his ledger is larger in external information than the previous one when related to the internal information:

[77] Whether $\Delta H[<, >, =]0$

Item	ΔH_g	ΔH
UCS 1	+1	-1
UCS 2	+1	+1
UCS 3	+1	0

One might argue that this presupposes a direction of time, but this is not the case. The events as recorded to hot happen in time, we are saying that in his ledger, $H_g^1 < H_g^2 < H_g^3$, the order of which is partial and not necessarily directed since Gabriel is outside of time. Furthermore, as we will explore in 4.2, external information can be mapped onto internal information in the form $\Phi H_g \rightarrow H$ (Φ maps x$\in H_g$ to Φ x$\in H$). From this we get $\Delta H \neq$ time direction. Here x is the internal information of the system. Thus, we have a universal asymmetry in information; the succession of UCSs[78].

There are two questions of scale here; that of time and that of distance. In this example, in the short term, time has no arrow because the entropy of the whole system is constant. However, if we wait a while, the entropy of the overall system will presumably start increasing, and so time will have a direction. So, whether time has a direction depends among other things on the size of the time intervals we are willing to consider. Despite this, we can still say that if Gabriel sits at the Informational center of the universe, he can be said to produce records indicative of a universal time. If we take into consideration a long enough scale of time, S_b will eventually increase. Gabriel's picture will then be of some positive number. We will then have $S_{nt} = S^+$. Furthermore, on a cosmological scale, it is less clear that this experiment would be indicative of time across the universe given its immense scale.

4.2 The Cosmological Observer

We have identified a method of determining a universal time for the laboratory universe. Now we will see how this can be generalized to a cosmological scale. Gabriel's cross sections

[78] One might argue that this ledger can be read in both directions, which is not consistent with the probability argument of section 3

are possible from the Archimedean "point from nowhen", an atemporal point from which we can view the universe. We take angel Gabriel to be at this point, which in this experiment is at the center of the boxes. His mind records every event, in both boxes simultaneously. When applying this to the universe as a whole, Gabriel must then be in the informational center of the universe.

After some considerations about the GTR, we are going to argue that external information H_g accounts for a universal asymmetry of information. His arguments based on information theory and entropy suggest that differing rates of increasing entropy across separate systems preclude a singular, information gradient. Thus, Reichenbach, Boltzmann, Einstein, and many others would argue that there is no possibility of defining a universal time series.

There are four primary concerns I must address before universalizing the laboratory experiment: (a) The limits of the branch model, (b)the expansion of the universe, (b.1)event horizons, (c) wavefronts, and (c.1) particle horizons.

(a) The branch model, local entropy gradients have direction, but the overall entropy gradient does not. Thus, there can be two sections of the entropy curve with opposite entropy directions, thus opposite temporal directions. Therefore, defining a universal time would not be able to account for such conflicting time sequences.

(b) The expansion of the universe brings about two primary problems in b and c.

(b.1) Given the expansion of the universe by $v = H_0 D$ there are sections of the universe that have not shared L, and thus never will. We thus have have $v = Hr$ where v is the speed of recession of a distant galaxy, its distance r, proportional to H, the Hubble constant of proportionality. Based on our conversation of simultaneity in Section 3, we cannot put them into temporal ordering with one another since their information states are not in contact with one another and placing them in temporal order relative to one another is impossible: their temporal relation is undefined. For waves and particles, this limit applies. Event horizons

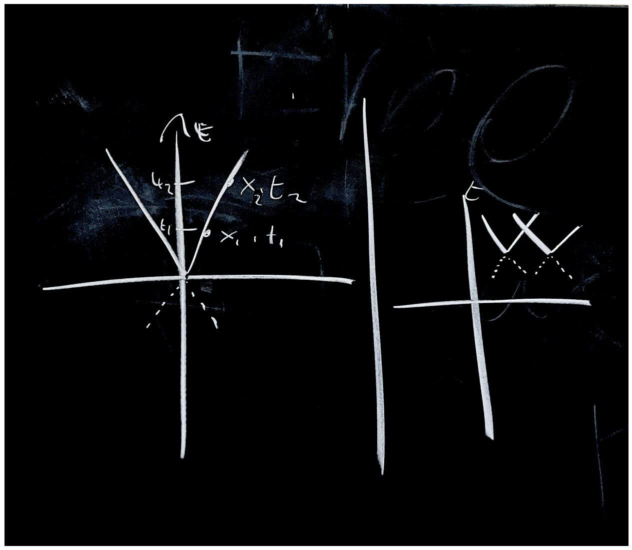

Figure 7: Light Cones (left) Intersecting Light Cones (right)

are defined if a photon will reach us at t= ∞[79].

(c) The wavefronts divide galaxies into two classes, those inside the wavefront that are visible, and those we cannot yet see because of the finite age of the universe.

(c.1) The wavefronts describe the second type of horizon, particle horizons, which are the maximum distances light could have traveled to us since the beginning of the universe.

Events separated in one or multiple of these ways cannot causally influence one another. So, to have a universal observer in Gabriel, we must rectify these phenomena. We are going to rectify the five issues mentioned above to establish how a universal observer can establish a partial ordering of events universally. To account for (a), we must take a bird's eye view of time, considering it a change in direction like we would any other. As for (b), (b.1), and (c), we must take into consideration the expanding universe from Gabriel's perspective.

Gabriel's view is often referred to as a comoving frame viewing the universe instantaneously. Recall from the previous section that Gabriel is at the theoretical intersection of light cones in the laboratory universe. Therefore, he is in such an intersection on a universal scale (Fig 7). The particles that formed the gas in the laboratory experiment can now be considered to be stars or galaxies, the molecules of the cosmic gas. We are left with Figure

[79]Davies 1974, p.88

Figure 8: Expanding Universe and Entropy Directions

where by Boltzmann's H theorem, the universe's entropy is increasing. Practically speaking, this perspective is impossible (as of now) but we are in search for what it would take to have a definition as such.

We want to define what information is present in his mind, thus representing the information gradient of the universe. Let us take a closer look at Gabriel's record, such that his mind is a registering device, observing the universe from Archimedean point from nowhen. Archimedes' point exists with a view from nowhen such that it is a maximally small point that is separate from the physical system such that it does not act on it, given that Gabriel is a disembodied soul.[80]

Gabriel's record of universal cross sections functions as point events where each point is a UCS. "The point event $\{\mathrm{x},t_x\}$ then would keep records of the total universe at time t_{x-1} [...] because a knowledge of what happens later at the volume's boundaries can only be acquired at later times"[81]. Thus, Gabriel's view, the point event $\{\mathrm{x},t_{x-1}\}$[82], can be mapped to the information of the universe at a given instant after the event happens. Since light is

[80] Regardless of the possible interpretations one might have, the experiment presents no inner contradictions and pushes the conceptual limits of time's reduction to entropy. Specifically, this experiment, built on Boltzmann and Reichenbach, follows Boltzmann's philosophy that his work "gives an incentive, not only for speculation, but also to do experiments (on [...] the size of the sphere of action[...])"(Boltzmann 1896, p.448)

[81] Reichenbach 1956, p.86-87

[82] Here the point events, on the universal scale, are singular UCSs

the fastest method of transmission of information in the universe, Gabriel's UCS mapping is restricted by the speed of light, we assume Gabriel is at a point, equidistant from every spatial point such that every piece of information reaches him at the same instant such that he is positioned at the intersection of all light cones, resolving the event horizon issue in (b).[83] These snapshots, as they exist in Gabriel's mind, reflect the traces of the interaction between the disembodied soul as a registering device and the time bound universe, with time's passing throughout the entire universe. We are further able to escape the problem of simultaneity if Gabriel is at the middle point of every light cone. What is simultaneous for the angel is for the angel to have the universal cross-section and the successive ordering of such snapshots in the angel's mind which defines a universal temporal order in the succession of cross sections as well as a direction; the increase of information in Gabriel's mind.

For the point from nowhen to be equidistant from every point, recall the formula defining relative simultaneity $t_2 = t_1 + \epsilon(t_3 - t_1), 0 < \epsilon < 1$. We can generally only say this for groups of events that are causally related, but in the case from Gabriel's perspective, every event in space-time has this relation to him. Such a vantage point allows him to record a total instantaneous cross-section of the universe, similarly to the laboratory experiment. From this, we have given an account of the instantaneous universal cross section, as registered by the angel's mind, specifying the simultaneity further[84]. Thus, local branch systems summed to form the information that exists in the universe (sum of branch systems)[87]; $\sum_{H=1}^{n} = H_n$, the informational sum of the universe, where H_n is the information at $t_n - 1$ of each individual branch, and n is the number of subsystems.

[83]Alternatively, Gabriel could be located at the informational center of the universe, located at the emergence point of the universe; the place of the big bang. This way, we get over the branch model issue, but not the issue of horizons given the expansion of the universe.

[84]It is worth noting Aristotle's notion of actualizing potentialities[85] and definition of time as "a number of motion with respect to the before and after"[86] as being a method to understand the shift from the past to the future through the present. The question that follows is that: how can this be represented in more concrete terms useful to a physical description of the universe? Poincare in fact was in the search for relations, which he thought time was, because the objects they were tied to have been updated or lost to history

[87]What it would take to have an universal cross section of the universe with no delay, at an instant, would be $t2 = \epsilon^2, \epsilon = t3 - t1$ because the inequality captures the delay in information from the events to the observer. In the case of instantaneous information travel, there is no such delay. These two events are equal to one another in time

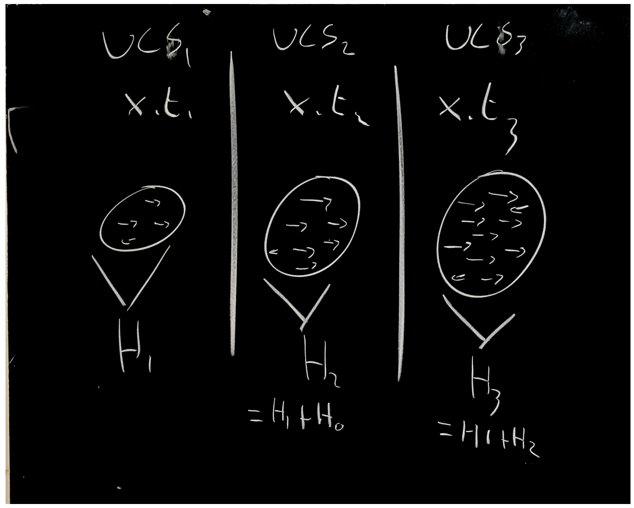

Figure 9: Gabriel's Memory as point events in the form of external information

Reichenbach calls the ordering of the universal entropy curve "supertime"[88] such that it has no direction but only an order containing individual sections that posses direction and order. This is distinct from Gabriel's perspective for two reasons: firstly, Gabriel is static; secondly, Gabriel has an asymmetric information gradient. In determining the overall entropy curve of the universe, we might want to infer that the future entropy will be higher, but given the symmetric nature of the entropy curve, this can be applied in either direction. However, we have Gabriel, who is external to the universe and is able to orient the universe relative to the additive size of the UCSs. So, at point event $\{x, t_0\}$, Gabriel has information state H_1^g, and at point event $\{x, t_1\}$, he has information state H_2^g such that $H_2^g > H_1^g$. The actualizing of each potential state of the universe from Gabriel's vantage point, is characterized by the quantity of information registered by his mind when the static UCSs are mapped onto the universe such that $\Phi\{H_n^g\} \rightarrow \{H_n\}$. The instantaneous universal cross sections are thus time slices of the universe at successive instants in Gabriel's mind. These successive instants are traces of the universal progression from the former state to the posterior state. We can thus model the information states in Gabriel's mind. Therefore, regardless of the internal information, Gabriel's information maintains a distinct asymmetry with each ordered UCS.

The universe, from Gabriel's point of view, is an individual isolated system. His view

[88]Reichenbach 1956, p.129

of the universe is an individual space ensemble and a singular specific recorded item such the two concerns regarding a) the causation problem and b) the issue of information are non-factors from Gabriel's perspective of the universe.

We can in fact use the probability assumptions referenced in Section 2 of positive relevance and screening off from Gabriel's perspective to define a universal time direction. The marks in his mind of point events {x,t_1} to {x,t_2}at t_2 and then t_3 such that $H_3^g > H_2^g$, suggests causal relevance between the two events based on the asymmetric size of information present in Gabriel's mind. We observe the causal additivity of marks, stemming from the asymmetric size of information. From this, we can produce an asymmetrical temporal ordering of UCS with an information gradient.[89]

When we were confronted with the increasing entropy of the universe, we posited the universe as static and of finite age filled homogeneously with constant luminosity of stars. These stars act as localized heat sources in cold space. Gradually, as L accumulates, the temperature of the universe rises. This is all fine and good until equilibrium is reached in the universe. However, in an expanding universe, there will always be a temperature gradient[90]. Thus, the temperature gradient is an asymmetric process that accounts for the ordering of the universal cross sections by internal information decrease.[91]

The direction of time is thus reducible to the mapping of partially ordered static UCSs of external information onto internal information slices from the perspective of a universal registering device, from Archimedes' point. Thus, we can define a universal time from the

[89]A sufficiently resourceful intelligence can tap energy and simulate black hole cannibalism, which is evidence that information, energy, can be said to exist even in a heat death universe. Thus, even in heat death, there is an increase in information in Gabriel's mind and potential energy is tapped.

[90]Davies 1974, p.95-96

[91]One might contest that there is entropy in the registering device outside of the experiment and that entropy is decreasing with every snapshot. This objection was raised to Maxwell by Brillouin and Szilard. They concluded that information acquisition would increase the entropy of the system such that the amount of information gained would be less than or equal to the amount of entropy increased (Davies 1974 p.54). But if we idealized a bit and had it such that the observer was at an informational middle point, right at the intersection of world lines, and we assume this observer exists in a point (taking in such little information it is almost negligible) then we would have a recording of static record of UCS. I argue that Brillouin and Szilard's cases are different because Gabriel here, existing on a point, external to the system. Further, I am appealing to the probability indicators from Gabriel's perspective that would likely not be affected by Brillouin and Szilard as well as the successive UCS argument.

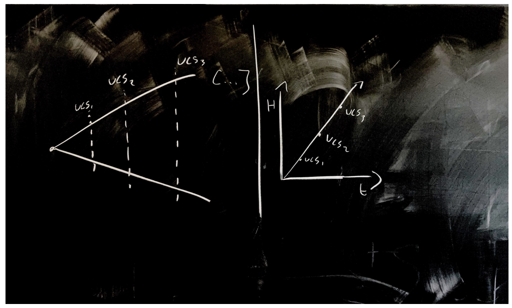

Figure 10: Gabriel's Information Cone

perspective of Archimedes point in terms of external lineal information size. This can be transformed into a weaker claim. In Gabriel's mind, from the point from nowhen, information is larger the farther away from the origin point he is because of his atemporal view of the universe, regardless of the increase, decrease, or stagnation of internal information in the universe since to Gabriel, a record that there are fewer bits of internal information in still more information; an additional state description for every time interval. Entropy theory and this non-traditional information theory do thus define an ultimate time direction. [92] We need a third kind of information in Gabriel's mind to define information asymmetry when mapped onto internal information.

We must ask ourselves what Gabriel's UCS ledger would tell us when $\Delta S = 0$ considering

[92]Gabriel's is fully isolated from the systems so we avoid the Gibbs paradox, preserving the additivity of information in Gabriel's mind. Thus, the entropy information theory provides a time direction for the entire universe from Archimedes' point. His information is constantly updating, despite the increasing macroentropy leading to decreasing information in Gabriel's mind. Since Gabriel, from Archimedes' point, is generating a specific recorded item of the entire universe, we avoid Reichenbach's problems. His registered information is always increasing, serving as a mark of the order and the direction of time as he updates his information record by one state description at a time, additively.

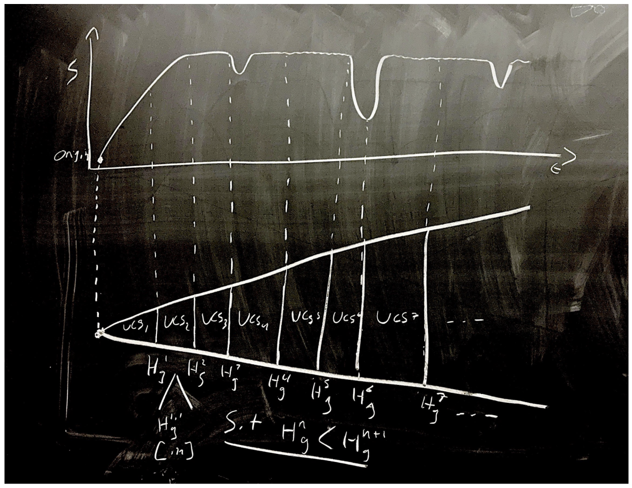

Figure 11: Universal Entropy Curve (Reichenbach 1956 p.111) Mapped onto Gabriel's External Information Cone

the universe is in equilibrium such that there is no internal information change. What will Gabriel see when the universe is in equilibrium? The internal informational change of the universe will be null, there is no change. The information that there is no change is itself a piece of external information. In a state of equilibrium, the ledger would read as it did on page 28 except filled with 0s for every H. Thus, we can have time without change when we map Gabriel's ledger onto the universe.[93]

5 Philosophical Implications

If there is truly a subject to which there is a perspective, then there is reason to believe in the existence of an ultimate perspective, an ideal observer. The information in Gabriel's mind corresponds to the information in the thing itself, the universe, where each cross section in his mind has a counterpart as apart from the universe. Time flow is the succession of universal cross sections as records in Gabriel's mind. Thus, the universe has an ultimate temporal direction as identified by Gabriel. We must note that what exists in the ideal observer's mind is a record of the universe, not the universe itself. Just as a seismograph's lines represent the movements of the earth, the movements are distinct in form from the graph. It is less

[93]See Ken Warmbrod's paper "Time, change, and time without change for more on this subject

clear how Gabriel acquires, or if we can even say he acquires, external information or if he simply has it brutely. Ultimately, there is no way for us to be certain there is such a flow or an asymmetry. We will ourselves be in the flow or in the block, registering it will be the same. What is the standard for us to be sure of the asymmetry?

Huw Price's major conviction is that if we are entitled to one direction of time, we are equally entitled to the other for deciding between initial and final conditions [94]. There is a large contention about what it would mean for the world to be equipped with a temporal direction. "The contents of time might be temporally asymmetric without itself having any asymmetry" p.20 "a law like temporal asymmetry does not require temporal anisotropy"[95].

Price argues that if time exists, then a temporal orientation is an intrinsic feature of space-time "beliefs and attitudes are objective in the primary sense" as "Objectivity is a method of understanding"[96]. From this, the subjective and objective are harder to decipher. If we step back far enough, to the edge of what exists, looking down onto the valley that is the universe, what would we see? From having access to every aspect of information from observation, Gabriel has maximum information available to a mind of our structure and function, but not stepping back from appearances all together; we are bounded to our memories, senses, and all that which produces a mark.

Huw Price rejects that there can be any perspective on time at all. For us to have an objective time, we must have a present moment that is objectively distinguished, such that time has an objective direction; that is an objective matter which of two non-simultaneous events is the earlier and which is the later, there is something objectively dynamic, flux like, or flow like about time[97]. We can define the present moment in Gabriel's mind as being distinct from the rest of moments: the moment at which the event is recorded, the information created. This can also be understood as the moment where the potentiality of acquiring information is actualized. Such conversations of information and the statistically

[94] Price 2009
[95] Price 2009, p.23)
[96] Nagel 1986, p.4
[97] Price 2009, p.2

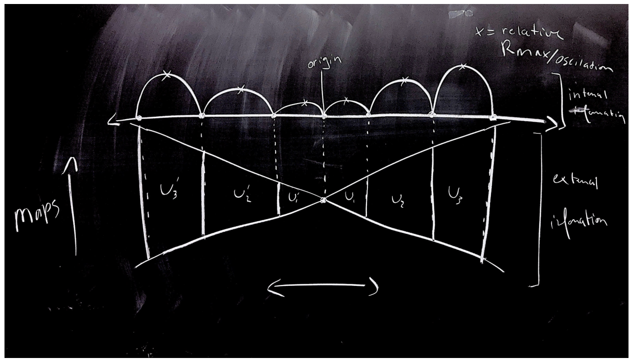

Figure 12: The Oscilating universe and Gabriel's information cones, distinct from the mapping process within each universe

defined causation are limited by the light cones each event belongs to. Causality, under this description, is thus that which is the strongest probabilistic indicator of an event, and more compellingly, conjunctive events. In fact, Gabriel's perspective at the limit of the universe is consistent with a great deal of the theories of the universe, both in physics and metaphysics.

6 An Oscillating Universe?

The most consistent view of this universal picture is the oscillating universe. In the oscillating universe, we have each UCS as successive iterations of a larger Rmax, the maximum amount of internal information in the universe, than the previous one[98], thus defining an objective direction of time as recorded by the mind of Gabriel. Rmax here is the maximum value of the amplitude R of the information present in the universe. In the oscillating universe, with a gradual growth of Rmax after every collapse to a singularity, this would coincide with the asymmetric size of information in Gabriel's mind and thus a direction of time.

Gabriel, as an ideal observer, can account for the oscillating universe. We can also have an oscillating universe that expands to Rmax then contracts to its final density state, with every successive state having an increasing maximal R, which Gabriel is counting. The oscillating universe can account for the apparent symmetry of the universal laws, as each oscillation happens in accordance with said laws. Whether you read the information as decreasing or

[98]Davies 1974 p.90

increasing within the universe, we observe the oscillations forming a slope, from the smallest amount of information to the largest amount.

The oscillating universe can provide a way to have a view of the entire universe from a universal perspective, both from the intersecting light cones and the center of the universe at the early stages of the universe because it is of small enough scale for the event horizon to have problems (b)-(c). We would have this state two times each oscillation. Given the asymmetrical nature of the oscillations, we have not only the asymmetry in Gabriel's information, but also, in the total information present in each successive iteration of the universe. Here we see another account of universal temporal asymmetry and a good argument for a direction as well.

We can say that each oscillation is larger in size from the last, away from the origin point due to Gabriel's asymmetric size of external information in his ledger when mapped onto the corresponding UCSs given that the ledger itself has an asymmetric information structure such that the first page contains less information than the latter pages since the latter pages build on the earlier pages.

7 Conclusion

We cannot be separated out from time, as being in time, and as beings whose experience depends on change. Asking a human about what it would be like to experience without time is like asking someone to think about shapes without any color, not white, not black, not anything, just a pure form without constituent matter. It is equally, if not more difficult, to think about the privation of time. Time cannot be separated from change and physics because time is written into their definitions and time parameters. Thus, the value of philosophy in this discourse is to separate the concept of time such that it is able to describe our real experience of time and the physical description in physics. The philosophical methodology compliments that of physics.[99]

We have answered the questions we posed about time here, accounting for temporal asymmetry in our minds and in the universe. To reiterate, internal time is consistent with the direction of the local system's tending towards maximal entropy, and the direction of the universe is in accordance with the larger size of external information in Gabriel's mind when mapped onto internal information states.[100]

From a maximally idealized perspective, we can define time in terms of the lineal size of information in the ideal observer's mind mapped onto the internal information. Gabriel's viewpoint suggests that we have time, which requires that external information cannot be destroyed. Gabriel, on the account of successive *nows* from a registering device of the universe, would register time moving a and b as a photographer registering leftward and rightward movement. No matter which way the subject moves, he sees them, moving forward in the time of his mind. But why? What is all of this to say? From the heavens, the angels always see time positively. Boltzmann states this rather clearly:

> "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 noticeably from thermal equilibrium, and indeed the state probability in such cases will be equally likely to increase or

[99] To Professor Price, if we can't really have a universal time, then it makes no sense to have a block universe view of the universe, only relatively small worlds standing in non-temporal relationship to one another. How would we explain the relativity of the world without appealing to a universal state?

[100] We have an interesting point we can draw from this idea of external information. Information in a void can be recorded by Gabriel where the internal information bestowed onto his point of view happens at a constant L with an intake rate c (the speed of light). The synchronization of the light cones was inspired by Warmbrod (Warmbrod 2017). This defines one rate at which each UCS is taken but from within the temporal framework.

> 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)."[101]

Boltzmann would say that there is a difference in the partial ordering of point events (a to b and b to a) only with respect to a particular perspective or choice coordinate frame, but there is no "correct" coordinate frame[102]. A relativistic spaceitme is temporarily orientable iff there exists a continuous everywhere defined timelike vector M if such a field exists, reversing the arrows gives another such field. the choice of one of those fields as pointing the way to the future is what is meant by the assignment of a time orientation[103]. In this paper, I have argued that there is such a perspective, with a new kind of information, in theory: Gabriel's perspective and external information. I can extend this conclusion one step further. Outside of time, change can be defined in terms of the mapping of static external information onto the internal information.

We do not observe time directly, and like causation, we only observe successive states. We must find time in these successive states, mental and physical. From our investigation we notice that what we experience in positive time is the growing swath of information. In opposite time, we would thus observe a decrease in information. However, from the universal perspective Gabriel has a bit of external information from both positive and negative time. There is only one direction of time since, if Gabriel is watching, then time necessarily progresses forward where forward is in accordance with the information's place in the ledger, which is always asymmetric in nature. There is further reason to believe that we are in an anomalous state, and that the universe, tending towards disorder, is in fact decreasing

[101]Boltzmann 1894, p.447
[102]Price 2009, p.5
[103]Earman and Wuthric

in information. Even though this appears to conflict with the conservation of information principle, we are making a claim about the observation from Archimedes' point, measuring Gabriel's information, which is compatible with a universe whose information is increasing, decreasing, or both.

Though we have not proved directly that there can be a universal time, we have shown that time, as perceived by registering devices, is determined both in order and in direction by the size of external of information, can be applied to the universe from the point from nowhen. Gabriel is in fact, counting *nows*, as Aristotle would say[104] given that, for Aristotle, time is "a number of motion with respect to the before and after"[105]. Time is the form of change, in an Aristotelian sense.[106] Time's reduction to change originated with Aristotle and was modernized in McTaggart: "There is no time without change"[107][108].

From my discussions with Professor Price, there is something we must consider; how does our entire discussion of time add to the block universe view? Huw told me to ask myself: "What aspect of my proposal is missing from a block universe depiction of the universe?[109]"[110]

One possible answer might lie in the experiential aspect of time. "The reason for our participation in such a staggeringly rare occurrence is attributed to the fact that the formation of biological matter itself requires thermodynamic disequilibrium so produced; humans could not exist to observe equilibrium state."[111] Despite humans not being able to exist in an equilibrium state, Gabriel's ledger has an entry for an equilibrium UCS too.

[104] Aristotle physics 1.5-9

[105] Roark 2011

[106] The universal time is just the $\sum S_n$ because the universe is equal to the sum of its parts. Any sections of the universe that has no entropy change due to void issues simply account for 0.

[107] McTaggart 460

[108] If we posit that Gabriel is outside of time and has the entirety of the universe in his vantage point, then we would have a block universe view. One possible explanation is that he has a complete registry of every single event, past and future. But we would need to explain why the universe would be cone shaped in either direction. The universe would likely be a cone shaped.

[109] Price 2024

[110] This leads us to an interesting idea; describing things in terms of causality and not finality is by the proposition of a new principle: that which is produced, following in time, always possesses more information than that which proceed it, from the perspective of the ideal observer.

[111] Davies 1976, p.103

In determining the direction of the arrow, we must be able to account for why external information would have an asymmetric structure. Further, for the block universalist, they must be able to account for *the moving spotlight*, what is *the now*, how we are in the now, and how this representation is consistent with our physical descriptions of the universe. One might argue against the block universalist insofar as the block universe theory conflicts with the branch theory in quantum mechanics[112].

I wanted to show how a registering device from an atemporal point can account for temporal asymmetry by successive universal cross sections, characterized by a lineal ordering of total external information size. Essentially, I aimed to provide an account of time in terms of information increase. If my argument holds, this is the new definition of time that emerges:

> The flow of time is the measure of change (Aristotle) from a less probable to a more probable state (Boltzmann) as recorded by registering devices by the production of marks (Reichenbach) of external information from causally connected local subsystems of the universe, lineally ordered, from a privileged reference frame; Gabriel's perspective. Time is thus, from Gabriel's perspective, the lineal ordering of successive universal cross sections.

Tangentially, the subjective experience of time, from inside any given frame of reference, regardless of the physical processes, will always be identified as moving forward, away from their relative past and towards their relative future. This subjective asymmetry is an invariant aspect of temporal experience not captured in the physical model, as defined by the probability axioms presented in Reichenbach.[113] Despite our efforts, we have not yet shown

[112]Then one could argue that we see causation to presuppose an arrow, except for the information transmission in the work of marks. How can we account for the direction of time without biasing one direction over the other? We see traits of what we see but not why we see it. We can say information cannot be destroyed, but what if it can equally never be created as we are looking at this through the lens of positive time. We have not yet answered why it is that time flows one way or the other or even at all but what we can say is the traits we record. Why we move from smaller to bigger volumes is that it is more probable, not how, how we flow forward in time. Causation is a myth of learned association between what we perceive and what our best guess to explain them, never getting to the how of time.

[113]A possibility to argue against this definition in favor of the block universe about the passage of time in the block universe as a person reading a book. they move through the pages, the story builds, and flows from

what it means to have a positive time, that is ultimately positive, not simply relative. What would this mean? According to our inquiry, as it stands now, experiencing time is what it means to be. For to be is to experience time, whether it be a rock, a person, or a book, what it means to be is to exist, is to exist in time. For if there is no time, there is no information, so there is no being, no relations to bear and nothing to be. From all this nothing, this idea that there is nothing is itself something.

External information exists inside of Gabriel's mind, but it is unclear if we can ever acquire this kind of information. Further, I am unsure how to unify the external and the internal information together, but I have made an argument for their existence.

8 Future Work

There is a difference between what is recorded, perceived, or remembered and what is, independent of observation. The demystification of time has been my endeavor in this paper, but true succession, change, or passage remains mystical and must be decoded in subsequent work. Why should information be conserved, instead of destroyed? Maybe this answer lies in situations of bizarre time, as observed in black holes.

We might want to investigate this in an Aristotelian framework, from the actualization of potentialities. Aristotle's concept of time is a debated topic, which I am deeply interested in. I began my research there as time being the measure of change, the countability of change and movement. Without counters, it is unclear if Aristotle understood there to be time. On the other hand, it is possible for objects without minds to serve as records, registering devices maybe, counting the change by the generation of traces. A conclusion of this is that if we have no change, we would have no time, which is consistent with traditional account. However, from Gabriel's perspective, is it less clear if there is no time for him, or if there is simply no way of telling from our perspective and we need Gabriel. From the understanding

beginning to end, But the book did not change, the reader passed through the book. We are the characters being read, which we understand as the passage of time. The reader is simply reading the pages of our life, but there is no metaphysical change to the reader.

of time from a given perspective, as counter of *nows*, it is not clear what time is: is it determined by the counter or by the change being counted?

In my next work, I would like to explore the implications of Gabriel in physics, and how Aristotle's view of actualizing potentialities reflects reality, our perception thereof, or both. I think the by investigating Aristotle's metaphysics and physics into contemporary physical accounts of the universe, we can establish a more complete and thorough notion of time with deep implications in physics and philosophy. This work can also take on phenomenology of time. I would like to further explore how Gabriel can help us provide an argument for an oscillating universe. I think that even if Gabriel's account does not work for the entire universe, it can be used in early models of the universe.

This conversation is incredibly complex, broad, and could engulf many lifetimes to discuss with proper care, the surface of which can be but scratched in 40 pages and is better treated in encyclopedia format. This is the subject of future writings that I greatly anticipate with sweaty palms and racing curiosity. I feel like I cannot put the books down and shorten up this paper. I want to write this forever.

It is interesting that, when we discuss beginnings and endings, always and never, this is all spoken in temporal vocabulary. But when we are investigating being, what is, and time itself, we cannot use temporal vocabulary because it presupposes time! I want to investigate also if there is no beginning to the universe, time, and space and how we can have this conversation in atemporal terms.

I also want to further explain the objective-subjective distinction between objective and subjective time, how they can be distinct, and how one can have different concepts thereof. I am curious about how this thesis is applicable and useful to empirical research on time.

We must also consider this message from Williams: Let us hug to us as closely as we like that there is real succession, that rivers flow and winds blow, that things burn and burst, that men strive and guess and die. All this is the concrete stuff of the manifold, the reality of serial happening, one event after another, in exactly the time spread which we have been at pains to diagram. What does the theory allege except what we find, and what do we find that is not accepted and asserted by the theory?[114]

[114] Williams 1951, p.467

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