Change in Entropy as a Function of McTaggart's A-series and B-series

Abstract

This careful note is a very initial foray into the issue of the change in entropy with respect to both McTaggart's A-series and his B-series.

Introduction

For our purposes McTaggart's A-series is that series that runs from future into the present and then into past. The B-series is that series that runs from earlier times to later times [1].

For the entropy, S, of a system the second law of thermodynamics may be stated [2]

(1) $$\triangle S = \frac{dS}{dt} \geq 0$$

In this equation the variable t is a B-series. This is the change in entropy with respect to earlier times going to later times in the case of increasing t. We are led to the question of what happens when changes are defined with respect to the A-series.

A-series τ and B-series t

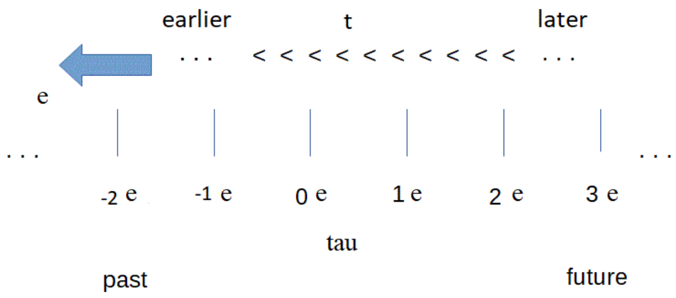
Let τ be a real variable that runs from a selected system's future into its present and then into its past a la McTaggart's A-series. We may define a unit of becoming, e, that coordinatizes τ the way seconds coordinatize McTaggart's B-series earlier-times to later-times (e is not the electric charge in this context). By convention we will suppose that $\tau > 0$ means the (A-series) time is in the selected system's future, $\tau = 0$ is in its present, and $\tau < 0$ is in its past. To avoid irrelevant complications we will suppose the rate of change of the B-series with respect to the A-series is constant in the domain of interest, see equation (2) below.

In this paradigm there must be some way to handle the constraints imposed by relativity. To do this suppose that an A-series is associated with each physical system the way that ontologically private qualia are associated with each physical system in Panpsychism [3]. Thus one system has an A-series τ and a different system has an ontologically different A-series τ'. The B-series is well-defined for time-like separated events in each system.

One doesn't need to make the sizable assumption the present is a single infinitesimally small point centered at $\tau = 0$. One may define for each τ a 'degree of presentness' $p = p(\tau)$, so the present may be spread out in A-series time somewhat, see [Appendix 1].

Basic Idea

Diagram 1



As later and later B-series times 'become' from the future into the present and then into the past in the A-series, time goes on [4].

Times in the B-series get later-than to the right and therefore increase in seconds to the right, but the A-series moves the whole B-series (in es) to the left (increasing es goes to more negative τ). It will be assumed that the series have been coordinatized so that the size of 1 second is the same size as 1 e: an event that is 1 second later-than, when it becomes, becomes 1 e further into the present from the future or 1 e further into the past from the present. Thus

(2) $$\frac{dt}{d\tau} = -1 \quad \frac{\text{sec.}}{e}$$

This says the rate of change of earlier times to later times of the B-series, in terms of the 'becoming' of the A-series, for each system, is -1 sec/e.

Given equations (1) and (2) we have

(3) $$\triangle S = \frac{dS}{dt} + \frac{dS}{d\tau} = \frac{dS}{dt} - \frac{dS}{dt} = 0$$

This says the change in entropy with respect to t and τ is 0. But this is only one possible definition of the change in entropy.

Open/closed Future and Past

(4) case 1: the future is pre-determined: given the present state of a system there is only one possible future, $f_{\text{pre-determined}}(\tau)$

(5) case 2: the future is not pre-determined: given the present state of a system there are multiple possible futures $f_i(\tau,\ )$. It is argued case (2) is the more plausible case in Appendix (2).

An experimental outcome is given only in the present. But in case (2) there may be many futures f_1, ..., f_n that are compatible with the state of things in the present. There are many possible definitions of entropy of the future to be tried. Two of these are the sum of entropies at a future time (τ, t)

(6) $$S_{future}(\tau, t) = \sum_{1}^{n} S(f_i(\tau, t))$$

and there is the possibility that the entropy at a future time (τ, t) is a function of all of the futures at that time at once:

(7) $$S_{future}(\tau, t) = S(f_1(\tau, t), \ldots, f_n(\tau, t))$$

Exactly the same considerations apply to the past. Thus,

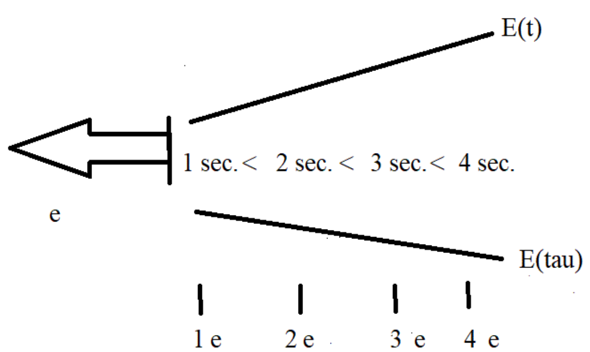
(8) case 3: the past is fixed: given the present state of a system there is only one possible past, p_{fixed}

(9) case 4: the past is not fixed: given the present state of a system there are multiple possible pasts, p_i

Case (4) is justified by the idea that experimental outcomes are given only in the preset, and there may be many pasts that are consistent with the present state of things. For example, it may be that at some earlier time in the past the function g = g(τ, t, p), where p is momentum, is consistent with the present state of billiard balls on a pool table. But it might be that another function of another triple g'(τ', t', p') is also consistent with the present state of the balls, where g and g' are not compatible with each other (i.e. cannot be part of the same history).

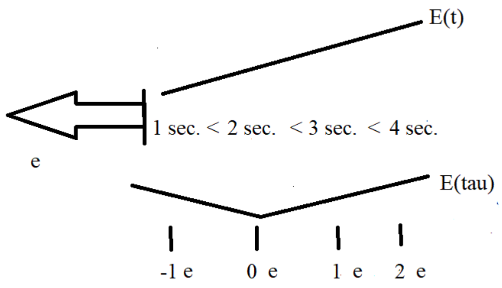
The physicist could try many functions. For example one can find functions such that qualitatively one has

Diagram 2



where only t and E(t) move (schematically), and they move to the left. And one can find functions such that qualitatively one has

Diagram 3



Where the present, $\tau = 0$, is a minimum for the A-series entropy, $E(\tau)$. Either of Diagrams 2 or 3 could be found given the right function in either case (1) or case (2), and in either case (3) or case (4).

In light of the unclear situation with units in equation (3) the physicist might also consider equations like

(11) $$\frac{d^2 S}{dt d\tau} = 0$$

and

(12) $$\frac{d^2 S}{d\tau dt} = 0$$

It may be that (11) can be ruled out on ontological grounds. We differentiate with respect to the A-series variable τ first. This leaves an A-series value for each of the B-series values of *t*. But in this case the A-series, and therefore the present(s), is(are) not ontologically privileged. This rules out equation (11). This requires further study and lies at the intersection of philosophy and physics.

Past Hypothesis

The Past Hypothesis is the hypothesis that the universe started in a state of low entropy and the entropy has, on average, been increasing ever since [5]. This is a problem because—all else being equal— a state of low entropy is enormously less probable than a state of high entropy. Thus the beginning of the universe was enormously less probable than it could have been.

Given equation (3) and perhaps equation (12) the past hypothesis problem would possibly be solved in some sense. This is only 'possibly' because even if one of these is right there is still the technical issue of the probability of the entropy of the universe being in a state $S(\tau, t)$. Here the A-series variable τ is related to how things could have been *given the way they are* (in the present) and the B-series variable t is related to how things are *given how they could have been* (in earlier times). This is an instance of 'two-dimensional semantics' [6] and also is at the intersection of philosophy and physics. It may be that equations (3) or (12) could help to adjudicate between (4) and (5), (6) and (7), and (8) and (9).

References

[1] J. M. E. McTaggart (1908). "*The Unreality of Time*". Mind 17: 457–73, see also https://plato.stanford.edu/entries/mctaggart/ It is worth mentioning that *also* in 1908 Minkowski introduced Minkowski space, Minkowski, Hermann (1908–1909). "*Raum und Zeit*" [*Space and Time*], Physikalische Zeitschrift, **10**: 75–88 Various English translations on https://en.wikisource.org/wiki/Space_and_Time

[2] Wikipedia, *Second law of thermodynamics,* https://en.wikipedia.org/wiki/Second_law_of_thermodynamics

[3] Stanford Encyclopedia of Philosophy, *Panpychism*, https://plato.stanford.edu/entries/panpsychism/

[4] Merriam, P., *Motivation and synopsis of the new theory of time*, https://philpapers.org/rec/MERMAS-4

[5] Stanford Encyclopedia of Philosophy, *Thermodynamic Asymmetry in Time*, https://plato.stanford.edu/entries/time-thermo/

[6] Stanford Encyclopedia of Philosophy, *Two-Dimensional Semantics*, https://plato.stanford.edu/entries/two-dimensional-semantics/index.html See also Internet Encyclopedia of Philosophy, *Two-Dimensional Semantics*, https://www.iep.utm.edu/2d-seman/

[7] Wikipedia, *Superdeterminism,* https://en.wikipedia.org/wiki/Superdeterminism

Appendix 1

One doesn't need to make the sizable assumption the present is a single infinitesimally small point centered at, for example, $\tau = 0$. (It may be the smallest duration is the Planck time anyway.) Define for each τ a 'degree of presentness' $p = p(\tau)$, so the present may be spread out in A-series time somewhat. By convention we will suppose $p(\tau) =1$ means that τ is fully present, $p(\tau) = 0$ means that τ is fully not present (thus either in the future or the past of the selected system), and $0 < p(\tau) < 1$ means that τ is partially present.

One may consider symmetric functions p, asymmetric functions, step functions, infinite-tailed functions, normalized functions, etc. It would be philosophically dubious to have a disconnected function p.

The block-world theorist would have $p(\tau) = 1$ for all τ. The growing-block theorist would have $p(\tau) = 1$ for $\tau \leq 0$. The presentist (like me) would suppose τ is at least partially present where $p(\tau) > 0$ (i.e. on the support of p).

Suppose again that an A-series is associated with each physical system the way qualia are associated with each physical system in Panpsychism. Then one system has a presentism function $p(\tau)$ associated with its A-series, τ, whereas a different system has a presentism function $p(\tau')$ associated with its A-series, τ'.

Appendix 2

Three arguments the future is not pre-determined:

(13) state-vector collapse in quantum mechanics is random (to within the relevant probabilities).

(14) quantum statistics in Bell experiments: Suppose there are two entangled electrons. Suppose Alice chooses of her free will the orientation of her Stern-Gerlach device and measures the orientation of the spin of the electron that goes through her device. Suppose Bob then chooses of his free will the orientation of his Stern-Gerlach device and measures the orientation of the spin of the electron that goes through his device, at events that are space-like separated from Alice's choice and measurement outcome. One expects the classical correlations in experiments. But one gets *greater-than-classical* correlations, namely the quantum correlations.

Suppose the statistics of this (previously entangled) pair of electrons, even if up only to stochasticisity, is a function of events/processes in the intersection of their past lightcones. Extrapolating backward, one gets to the big bang. This, super-determinism, establishes all correlations in the universe at the big bang [7]. But then why don't we see *greater-than-quantum* correlations? … Certainly, there would be correlations up to 100% in the long-run statistics. But we *never* observe such greater-than-quantum correlations, only quantum correlations. Therefore, the observed statistics of the universe are not consistent with the theory of super-determinism. Instead, they are consistent with free will.

(15) free will in some philosophical sense: this is already persuasive to many researchers.