McTaggartian Spacetime: physics in the new theory of time

“How does the [quantum] universe know when to apply unitary evolution and when to apply measurement?” [Aaronson 1]

A new theory of time proposes that unitary evolution applies when two systems do not share the same A-series, and a quantum measurement applies when the two systems come to (or 'become to') share the same A-series. [Philpapers 1]

This careful note is an invitation to cooperate in the development of a theory which is a *work in progress* whose more proper introduction is being written up in a paper that is also in progress. This preliminary attempt is to bring McTaggart's A-series and B-series into physics. Though not yet published it is very likely that at least *some* of this is correct.

Minkowski (1908), McTaggart (1908)

In Minkowski space there are 4 dimensions and its metric is given in terms of 1 time parameter and 3 space parameters, (t, x, y, z). [Minkowski 1] The 3 space parameters accord with our experience, but the 1 time parameter does not. As McTaggart explained, time that accords with our experience is given by 2 series, the A-series and the B-series. For our purposes, McTaggart, also in 1908, defined the A-series, τ, as that temporal series which runs from future to present and then to past, and the B-series, t, as that series which runs from earlier-times to later-times. [McTaggart 1] τ and t can be varied independently (depending on the situation) so a notion of time that accords with our experience *cannot* be given by just 1 parameter t.

Thus, to model 'spacetime' that accords with our experience, we need the 5 variables (τ, t, x, y, z). In this 'McTaggartian spacetime' or 'AB-spacetime', τ represents the position of an event in the A-series of a given system, t represents the position of the event in the B-series of that system, and x, y, and z represent the spatial positions of the event. This is worth repeating: AB-spacetime is given by *five* variables and not *four* as in the case of Minkowski space. [Appendix]

A system can be any physical closed system and in particular is not assumed to be macroscopic or conscious.

Just as the B-series can be coordinatized by a unit 'second', the A-series can be coordinatized by a unit 'e' (perhaps 'd' would be a better name? the unfortunate name 'e' does not designate electric charge, in this context). 'e' is the unit of becoming, namely, becoming from the future into the present and then into the past of a selected system. A change of 1 second is a change in the B-series, and a change of 1 e is a change in the A-series.

Rates

Let x be the position of a point particle defined relative to a chosen origin in a particular system. One may define dx/dt, the 'rate' at which the position of the particle changes with respect to the B-series time t, i. e. with respect to the 'time' going from earlier times to later times, in units of meters/second.

One may define $dx/d\tau$, the 'rate' at which the position of the particle changes as it 'becomes' from the system's future into the system's present and then into the system's past, in units of meters/e. This neither assumes nor implies the future is predetermined, as there may be many futures which are consistent with the system's present.

One may define various 'rates of time' in units of seconds/e. A rate of 1 second/e is a process that goes 1 second later-than, in the B-series, for every e it becomes from the system's future into the system's present and then into the system's past in the A-series (assuming the obvious coordinatizations). A rate of 2 seconds/e means the process goes 2 seconds later-than, in the B-series, for every e it becomes from the system's future into the system's present and then into the system's past in the A-series. (Of course this puts aside complications about reparameterizations as well as substantial changes in the relationship between τ and t.)

Since 1905 it's been known that simultaniety et al. is relative. [Einstein 1] This can be handled by supposing a *perspectival ontology* as indexed by the A-series parameters, namely, 1. each system has a (its own) compliment of 5 parameters (τ, t, x, y, z), 2. simultaniety is a property of the B-series parameters of different reference frames t, t', …, and 3. if two systems have different A-series parameters τ, τ'', … then the two systems form different ontological perspectives, are related quantum mechanically, and, in particular, are not in the same AB-spacetime.

Condition (3) allows us to suppose that, for example, the 'now' of Schrodinger's Cat is not the same as the 'now' of the Experimenter E standing outside the box, until (mutual) quantum observation. Or that the 'now' of a system of two entangled electrons is not the same as the 'now' of a experimenter-system Alice, until quantum observation. Indeed if E's A-series variable τ has a definite value then Cat's A-series variable τ'' does not have a definite value, and *vice versa*.

Condition (3) was independently philosophically motivated but the philosophy is left out of this note. [PhilPapers 1]

McTaggart on Newton

“Absolute, true, and mathematical time, of itself, and from its own nature, flows equably without relation to anything external, and by another name is called duration: relative, apparent, and common time, is some sensible and external (whether accurate or unequable) measure of duration by the means of motion, which is commonly used instead of true time; such as an hour, a day, a month, a year. ” [SEP 1]

We can parse this as

“Absolute, true and mathematical time, of itself, and from its own nature flows equably without regard to anything external, and by another name is called duration” This is the A-series. [SEP 2]

“relative, apparent, and common time, is some sensible and external (whether accurate or unequable) measure of duration by the means of motion, which is commonly used instead of true time; such as an hour, a day, a month, a year.” This is the B-series. [SEP 2]

The new thing since 1905 [SEP 3] is the constraint of being consistent with relativity. This is handled by the B-series of the respective systems in this preliminary theory, though with further development it probably will turn out that both the A-series and the B-series are involved (in addition to the spatial coordinates).

Preliminary notes on perspectival ontology

Suppose that for an experimenter E, Schrodinger's Cat is in the state

(1) $|\Psi\rangle = c_1 |\text{will find cat purring}\rangle + c_2 |\text{will find cat meowing}\rangle$

in a Hilbert space H. Every physically instantiated system must be able to describe other systems by quantum mechanics (complications arising from field theories are not discussed in this short note). Therefore, as described by Cat, E is in an analogous state

(2) $|\Psi''\rangle'' = c_3 |\text{will find E that finds cat purring}\rangle'' + c_4 |\text{will find E that finds cat meowing}\rangle''$

in a different Hilbert space H''. The long-run statistics of the first and second terms in (1) and (2), respectively, must be the same, so in view of the Born rule we have

(3) $|c_3|^2 = |c_1|^2$ and $|c_4|^2 = |c_2|^2$

...

But not so fast. It is the interface of AB-spacetimes from two ontologically distinct *perspectives,* such as E and Cat, that is (in this model) quantum.

It could be argued that before quantum observation we in fact have (in obvious notation)

(4) E's 5-dimensional AB-spacetime (τ, t, x, y, z) from the ontological perspective of E,

(5) Cat's 5-dimensional AB-spacetime (τ', t', x', y', z') also from the ontological perspective of E

and

(6) Cat's 5-dimensional AB-spacetime (τ'', t'', x'', y'', z'') from the ontological perspective of Cat,

(7) E's 5-dimensional AB-spacetime (τ''', t''', x''', y''', z''') also from the ontological perspective of Cat

where 'before' means a quantum observation (such as E opening the box) is in the future of E and, analogously, in the future of Cat.

The 5 dimensions come from the need for an A-series, a B-series, and 3 space dimensions for each AB-spacetime.

Thus in E's ontological perspective there are in some sense 2 AB-spacetimes, the first one (4) and the second one (5). On the other hand, in Cat's ontological perspective, there are in some sense also 2 AB-spacetimes (6) and (7). So we would expect (4) and (5) on the one hand to be quantum mechanically related to (6) and (7) on the other hand.

What are the (not all independent) 64 (possibly stochastic) relationships between the 8 variables (τ, t, τ', t', τ'', t'', τ''', t''') before, during, and after quantum observation? (And what are the at least 625 relationships between the 20 variables where the space coordinates are included?)

Here is an observation.

An experimental outcome is revealed to E in E's present, τ = 0, and must be in Minkowski space (in the 'flat' case), so that the metric of E's AB-spacetime, in E's ontology, at τ = 0, must conform to the Minkowski metric (putting aside constants throughout)

(8) $\Delta s_{AB\text{-spacetime}}^2$ (at τ = 0) = $\Delta s_{Minkowski\text{-spacetime}}^2 = -\Delta t^2 + \Delta x^2 + \Delta y^2 + \Delta z^2$

This raises the following idea. Suppose that, for general values of τ,

(9) $\Delta s_{AB\text{-spacetime}}^2 = +\Delta\tau^2 - \Delta t^2 + \Delta x^2 + \Delta y^2 + \Delta z^2$

And suppose

(10) $\Delta t' = i\Delta t$

with the other variables in a real proportion to each other. Then

(11) $\Delta s'^2_{AB\text{-spacetime}} = +\Delta\tau'^2 + \Delta t'^2 + \Delta x'^2 + \Delta y'^2 + \Delta z'^2$

Then, where (9) gives an AdS_5 space (for E's AB-spacetime in E's perspective) in the coordinates (τ, t, x, y, z), and (11) gives an S^5 space (for Cat's AB-spacetime also in E's perspective) in the coordinates (τ', t', x', y', z'). The same geometry clearly obtains for the 2 AB-spacetimes from Cat's perspective, in the coordinates (τ'', t'', x'', y'', z'') and the coordinates (τ''', t''', x''', y''', z'''). This, given the previous proposition that E's perspective is related to Cat's perspective quantum-mechanically (before mutual observation), is suggestive of an AdS/CFT correspondence. [Maldacena 1]

References

[Aaronson 1] Aaronson, Scott, qclec, *Lecture 12, Thurs Feb 23: Interpretation of QM (Copenhagen, Dynamical Collapse, MWI, Decoherence)*, https://www.scottaaronson.com/qclec/12.pdf

[Einstein 1] Einstein, A., 1905. “On the Electrodynamics of Moving Bodies,” as reprinted and translated in *The Principle of Relativity*, New York City: Dover Publications, 1952, pp. 35–65. See [SEP 4].

[Maldacena 1] Maldacena, Juan, 1998. "The Large N limit of superconformal field theories and supergravity". *Advances in Theoretical and Mathematical Physics*. **2** (4): 231–252. arXiv:hep-th/9711200. Bibcode:1998AdTMP...2..231M. doi:10.1023/A:1026654312961.

[McTaggart 1] McTaggart, J. M. E., 1908. “The Unreality of Time,” *Mind*, New Series, 68: 457–484. See [SEP 4].

[Minkowski 1] Minkowski, H., 1908. “Space and Time,” as reprinted and translated in *The Principle of Relativity*, New York City: Dover Publications, 1952, pp. 73–91. See [SEP 4].

[PhilPapers 1] Merriam and Horne, 2020. *A new theory of time 2 29 2020*, https://philpapers.org/rec/MERANT-3

[SEP 1] Stanford Encyclopedia of Philosophy, *Newton's Scholium on Time, Space, Place and Motion*, https://plato.stanford.edu/entries/newton-stm/scholium.html

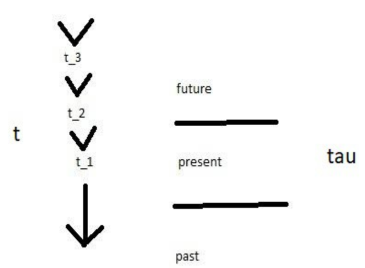
[SEP 2] Stanford Encyclopedia of Philosophy, *John M. E. McTaggart*, https://plato.stanford.edu/entries/mctaggart/

[SEP 3] Stanford Encyclopedia of Philosophy, *Space and Time: Inertial Frames*, https://plato.stanford.edu/entries/spacetime-iframes/

[SEP 4], Stanford Encyclopedia of Philosophy, *Being and Becoming in Modern Physics*, https://plato.stanford.edu/entries/spacetime-bebecome/

Appendix

This is a schematic of the new theory of time:



In the B-series timeline, t_1 is earlier than t_2 which is earlier than t_3... The earlier-times to later-times timeline remains in that ordering ('modulo' space-like separated events), but the whole timeline moves from future to present to past, with the present staying put. (The present does not 'move up the B-series' as in most theories because *ipso facto* the presents wouldn't be ontologically privileged.) As later and later B-series times become present, time goes on. The arrow indicates the 'becoming' that is a feature of the A-series.