Postscript for Physicists and Philosophers

Postscript for Physicists

(**A**)

For one dimension of time T(τ, t) and three dimensions of space the flat metric is

(1) $$ds^2 = dT^2(\tau, t) + \sum_{i=1}^{3} dx_i^2$$

Any experimental outcome is revealed to Alice in her present. Alice's present (or at least the center of it) is the condition τ = 0. (The general condition would use the presentism function p(τ) discussed earlier.) Also, any experimental outcome that Alice gets must be Lorentz-invariant, i.e. in Minkowski space in the flat case. Thus

(2) $$ds^2 = dT^2(0, t) + \sum_{i=1}^{3} dx_i^2 = -dt^2 + \sum_{i=1}^{3} dx_i^2$$

which imply

(3) $$dT(0, t) = i dt$$

This says the difference in time T is, in Alice's present, equal to *i* times the difference in (B-series) clock times.

Light is associated with a constant *c* that has units of meters per second. It is reasonable to wonder if there is something associated with a constant *b* that has units of meters per e. The thing would move a constant number of meters for every unit of becoming into Alice's present.

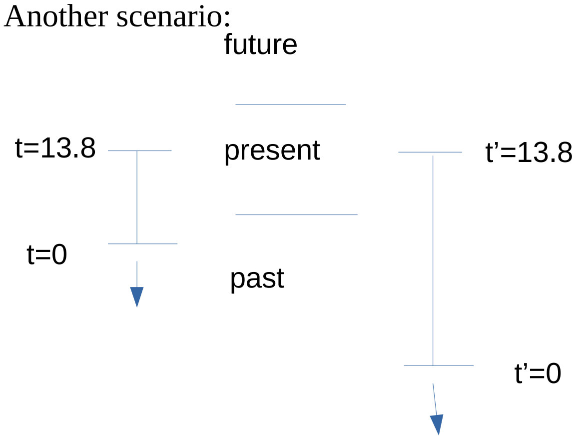
(B)

The condition that t = t', in appropriately scaled units, says that the event is simultaneous in both frames of reference, the un-primed frame and the primed frame. This is, of course, *not* the same condition that the event is in both presents, which would be the condition τ = τ' in appropriately scaled units (of e and e' respectively). The latter condition cannot be given in the A-series coordinates of two different systems.

(**C**)

The big bang may be getting earlier than the present, but that need not be at the same rate as the big bang going into Alice's past. For the sake of argument let the big bang be at time t = 0 and the time in which we live t = 13.8 billion years. This could mean the big bang is 13.8 billion years *earlier than* now. It is not always necessary that τ = t (in appropriately scaled units of es and seconds, respectively). It may be possible that, for example, $\tau \rightarrow -\infty$, in which case Alice must go infinitely far *into her past* before getting to the big bang. This interpretation would be the best of both worlds. It's 13.8 billion before now (the B-series), but if one tried to go back through time into Alice's past, (the A-series), in some models, one never gets all the way to the big bang. This bears on the question of whether there could have been a *first* moment of time.

Another scenario:



Supposing these B-series one at a time, in the B-series on the left the big bang is 13.8 billion years *earlier* than now. That is some particular distance in Alice's *past*. In the B-series on the right the big bang is also 13.8 billion years *earlier* than now, but it has gone further into Alice's *past*. There is the rate $r = dt/d\tau$ which is or tends toward 0 in these scenarios.

(D)

There is the question of the relationship between a quantum state and an ontic state. In the Ontological Models framework (OM) one models a quantum state by a distribution D over all ontic states [Spekkens, Leifer 2014]. These are parameterized by at most one time variable t. In AB-theory there is a distribution D1 over the ontic states parameterized by (τ, t, t') (Alice's A-series, Alice's B-series, and Bob/cat's B-series) and there is a distribution D2 over the ontic states parameterized by (t, t', τ'). There is no distribution D3 over states parameterized by (τ, t, t', τ'), as there would be in the OM model, because τ and τ' are ontologically private, in (or analogous to) the way the qualia of Alice and the qualia of Bob are ontologically private. Is this a kind of knowledge-restriction [Spekkens, Leifer 2014]? There's more information in D1 union D2 than there is in D3, but only one is given. There is the question of what this could say about the 'psi-ontic' vs. 'psi-epistemic' interpretations.

Postscript for Philosophers

(E)

Philosophers of time have developed *tense* logics and many others. Tense in this paper is associated with the A-series. And the A-series is supposed to be (or be like) the phenomenal, i.e. qualia. Therefore it is plausible that to get a start on finding the logic of qualia one could take a tense logic and modify it appropriately.

(F)

One might be willing to entertain the idea that, in obvious notation, the modal axiom

(4) $\Diamond P \rightarrow P$

is true for the A-series but false for the B-series. If it is true for the A-series then the mere *possibility* of the A-series presupposes the A-series. This is plausible: the possibility is itself temporally situated. Also one might expect that it is true of qualia and false of their physical correlates.

Third Postscript

(G)

One needs *more than 4 numbers* to locate an event in AB-spacetime. These are τ, t, and x^a. One specifies τ, how far in the future/present/past the event is, and t, how much later than t=0 the event is, and the three x^a. Of course τ and t are closely related.

(H)

There should be a theorem as to whether or not the 'now' of the cat and the 'now' of Alice (the experimenter) can be identified in some way, with the respective B-series not fixing each other. A C-series might be appropriate.

(I)

There is a time-reversal

(5) $(\tau, t) \rightarrow (\tau, -t)$

This means that as events go forward in Alice’s A-series (from future to present to past), the B-series times are going from later times to earlier times. This is the realization of the ‘movie going backward’ metaphor. This is at least one of the notions of time-reversal in physics. These time-reversals are dubious:

(6) $(\tau, t) \rightarrow (-\tau, t)$

(7) $(\tau, t) \rightarrow (-\tau, -t)$

except at τ=0 (or its generalization given by the presentism function p(τ)) because these would have to go through Alice's present. (A disconnected present would be philosophically dubious.)

(J)

Toward justifying the diagrams. One cannot say there is a 'now' in one location on the B-series and there is a different 'now' somewhere else on the B-series because then neither 'now' would be ontologically privileged. Ontological privilege implies there is only *one* 'now'. Yet since there is only one 'now' different 'times' would require different locations on the B-series.

There should be a way to represent the A-series 'becoming'. The B-series doesn't change (mod space-like separated locations, an irrelevance). So the A-series and the B-series must change relative to each other while keeping the same 'now'. The above picture is modified to

Moreover, this accords with experience.

(K)

Alice is supposed to describe the cat state in terms of time. For the interesting function *f*, with a Cartesian product x, one has

(8) $f(T(\tau, t), t', T(\tau, t) \text{ x } \tau')$

where the third term comes from the idea that, for each of Alice's times T, the 'now' of the cat, τ', could take on any value (on the future/now/past spectrum of the cat). One has,

(9) $f : \mathbb{R}^2 \times \mathbb{C}^2 \to \mathbb{C}$

to model quantum states

(10) $\Psi(t) : \mathbb{R} \to \mathbb{C}$

but, it should be emphasized, this could easily be wrong. One problem may be that the τ and τ' are in the same function. On the other hand, they are not symmetrical in *f* (which is necessary).

(L)

Let time $T_1 = (0, 0)$ and time $T_2 = (i\tau, t)$, normalized in some way. We can ask what is the probability that they become the same time, $T_1 = T_2$, at collapse? There is a probability $p_A(T_1 \rightarrow T_2)$. Here, T_2 is in the future of T_1, by τ, and also T_2 is later than T_1, by t. But p_1 is not the answer. An experimental outcome is revealed only in the present, τ = 0. So we would seem to want the probability p' ($T_1(0, 0)$ and $T_2 = (0, 0)$) but that's not right … These are ontologically private so we want the probability

(11) $p_{AB} = p_A p_B((T_1 \rightarrow T_2) \text{ and } (T_3 \rightarrow T_4))$

[diagram]

Here T_3 is at the time T_2 but given coordinates (0, 0). This implies T_4 (put at time T_1), will have coordinates $(-i\tau, t)$. If T_2 is in the future of T_1, τ, from the perspective of T_1, then T_4 is in the past of T_3, -τ, from the perspective of T_3. Therefore $T_4 = (-i\tau, t)$. Therefore

(12) $p_{AB} = p_A p_B$ (first transformation in (11) followed by the second transformation (11) = $p_A p_B(i\tau, t) \times (-i\tau, t) = p_A p_B |T_2|^2$.

The probabilities p_A and p_B are just 'probabilities', and not, in particular, some mysterious things that have the ontology of merely a 'square root' of a probability. A product of probabilities, p_{AB}, is a probability.

It's critical that to get the probability of the realization of the path one has the probability of (C to D) from the perspective C, *and*, the probability of (D to C) from the perspective of D. Before observation (collapse of the state function) they are not ontologically one system from which a typical coordinate system could be given.

This has an exact analogue (equivalence?) in the case of Alice's qualia and Bob's qualia. She looks at some leaves and sees green, i.e. green qualia arise in her consciousness. Alice knows that when Bob looks at the leaves he would see, because his brain is constructed a little differently, what she would call either burgundy, yellow, or purple were she able to experience them.

On the other hand, according to Bob, he sees some particular color when he looks at the leaves, for example yellow and Alice would be seeing what he would call green, blue, or red were he able to. (And Alice would have been in one of these states in the paragraph above.)

The question is, what is the probability that, for example, Alice sees green *and* Bob sees yellow. There is no ontological state that contains both Alice's qualia and Bob's qualia, so there is no probability distribution over one. Instead there is the probability distribution over 'Alice sees green and Bob sees yellow' according to Alice's ontology and her map of Bob's ontology, and the probability distribution over 'Alice sees green and Bob sees yellow' according to Bob's ontology and his map of Alice's ontology. Thus the probability that one has 'Alice sees green and Bob sees yellow' in one ontology is the product of these two distributions for the given cases.

References (forthcoming)

[Leifer 2014] “Is the quantum state real? An extended review of ψ-ontology theorems”, arXiv, https://arxiv.org/abs/1409.1570