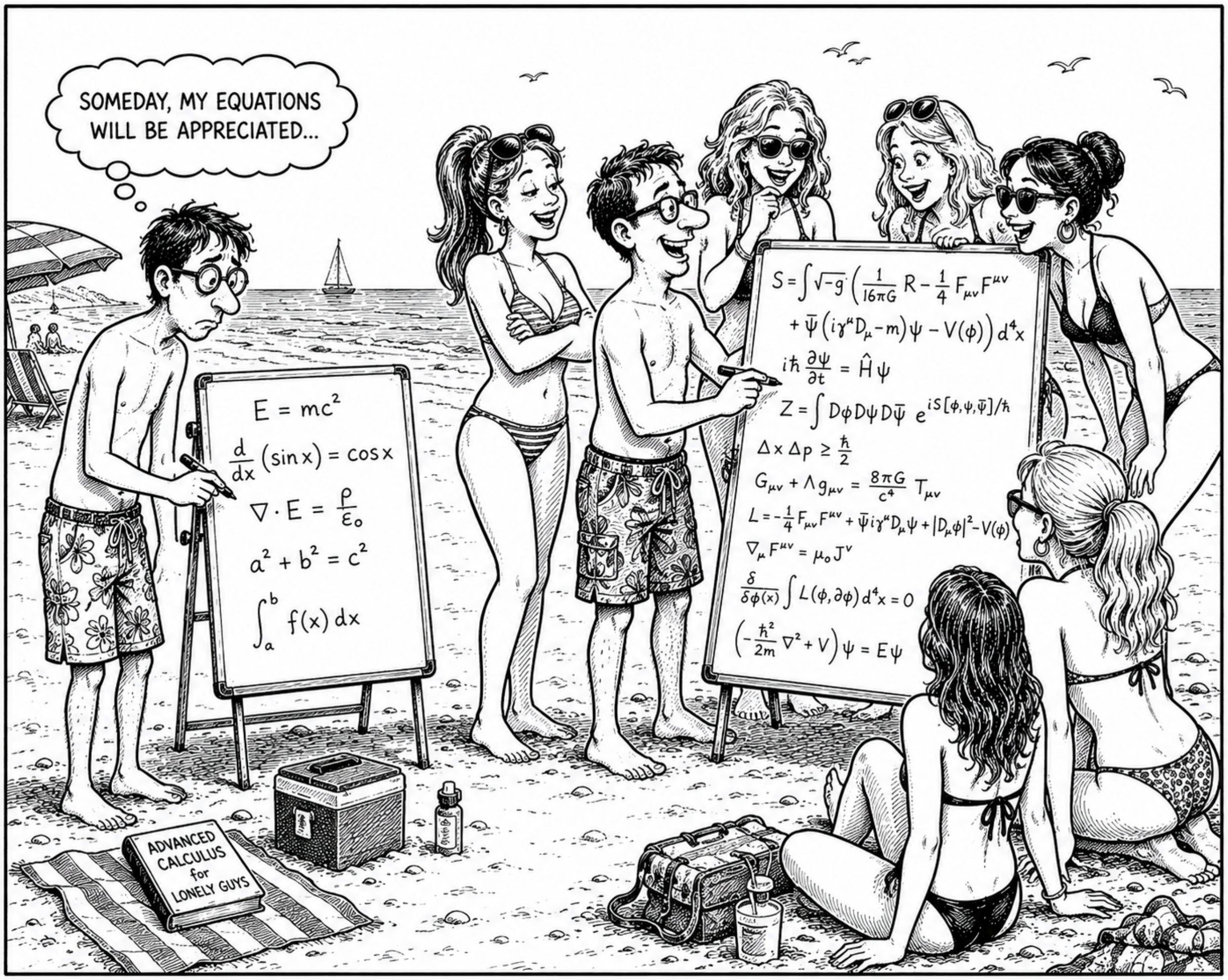
Chapter 23

"Critique"



Impressive Equations

Thesis

Self-referential closed causal loops in spacetime built with spacelike causes, that self-collapse in the one and only basis in which the loop is indeterminate, deftly avoiding temporal paradox, while acting as nature's censor mechanism to prevent causality paradoxes, with the side effect of allowing superluminal signaling.

If true it would

- Introduce nonlinearity into quantum systems in a natural way (via self-reference)
- Provide an objective measurement mechanism (when, where and why)
- Eliminate the arbitrary divide between quantum system and classical environment
- Specify the collapse basis
- Explain the source of randomness in quantum systems (indeterminacy)

- Locate decoherence along the separation collapse continuum
- Make time, space, and causality nonlocal in a compatible way
- Allow spacelike causality
- Permit superluminal signaling
- Permit *time travel like* technologies
- Reduce, possibly eliminate, the interpretation problem in quantum mechanics

Now for the hard work – figuring out testable, mathematical formalisms compatible with what we do know about quantum systems, that display these features. It is a tall order.

Formal Self-Reference

The declaration that imaginary truthvalues solve logical paradox is bold, inventive, almost surprising, but its formal development has stalled, with few active researchers in the field. Developing formal logic from Euclid to Bool to Gödel was a major task that in some sense failed. Useful, critical, but incomplete. High expectations of its power turned out to be premature and a little naïve, with the actual killing blow comping from, ironically, self-reference itself.

Can logic be saved, recreated from the ground up with self-reference built into the very foundations, where it can be controlled? Or despite our ingenuity, can it always find a way to sneak back in, late in the game and sabotage the whole enterprise?

Semi-Entanglements

Given a pair of two state particles, their joint Hilbert space is 4 dimensional, the product space of the 2 dimensional space of their individual states.

$$\Psi_{12} = \begin{Bmatrix} +\alpha|0\rangle_1|0\rangle_2 + \beta|0\rangle_1|1\rangle_2 \\ +\gamma|1\rangle_1|0\rangle_2 + \delta|1\rangle_1|1\rangle_2 \end{Bmatrix} \tag{1}$$

Every case where the squares of the four coefficients (complex) sum to unity is, in the mathematical formalism of the theory, an allowed state of the system. If the magnitudes are equal, the state is separable, if one is zero and the rest have equal magnitude, then the state is a semi-entanglement, if two are zero and the rest have equal magnitude, then either one particle is in a pure state (row or column) or they are in an EPR entanglement (a diagonal is zero), if three are zero, then both particles are in fully classical states.

The case of only one coefficient being zero is recognized in the physics literature as a special point but has never been named. In this work, we refer to states of this general form as *semi-entanglements*.

Now there is a concept in QM called the Schmidt rank. It is discrete, integer values only. A separable state has a Schmidt rank of 1, a Bell state has a Schmidt rank of 2. No *unitary*, *local* operator can change the Schmidt rank. Thus, given a random state in a Hilbert space, that point is a member of manifold that does *not cover the entire space*. The seam points between the manifolds are *singular* – a hallmark of chaotic systems, which indicates hidden self-reference.

Semi-entanglements have a Schmidt rank of 2. The relationship between states with different Schmidt ranks are not symmetric.

The mathematical isotropy of Hilbert spaces are broken by basis and the tensor partition. It is *not the case* that one basis is as good as any other. One is not chosen for its mathematical convenience; one is chosen for its physical appropriateness. The singular surfaces are not basis dependent, they are determined by the physical setting, but the view of the surfaces from different bases are not the same – and it may turn out that only some views are internally consistent.

As feared, Hilbert spaces are red-herrings.

While Schmidt rank and entanglement strata are invariant, their geometric realization – including the visibility and severity of singular boundaries – depends strongly on the chosen tensor partition and basis representation.

Pruning by Contradiction

In QT3 pruning of the classical ensemble occurred by contradiction. A spooky mark implied two squares in every game in the ensemble, and it did not have to be legal in all of them. The formal requirement was that it had to be legal in at least one but in practice this made it legal in at least two.

What is the equivalent of contradiction in physics? Fermi exclusion principle? Just the avoidance of inconsistency? Do the Schmidt numbers, in particular the Schmidt rank, offer any insight here. This looks like a deep dive even before we consider the effect that conjugate bases are going to have on this issue.

Symmetric Spacetime Intervals

Clever little idea, claiming there is a spacelike growing connection between a pair of entangled particles from the moment of their inception. Allows us to tell left from right. Given two spacelike events for the detection of a pair of EPR entangled particles, the symmetric interval runs into the spacelike interval that connects those detections in a nonlocal way, what we called a zipline. The zip runs either left to right or right to left and this ordering is a relativistic invariant – all observes will agree on it.

Presumably, the event at the start of the zipline is the cause and the event at the end of the zipline is the effect, but there is no loss of consistency if the causality runs in the opposite direction. But how do you test this idea? You would need a superluminal signal.

The derivation uses the relativistic doppler equation and so does not apply to matter particles. The easy generalization that the center of mass of a system provides a privileged frame is unlikely to survive extension to matter particles for the center of mass is not a relativistic invariant.

And that is not the end of the difficulties. What about entanglement swapping? We now have two entangled particles but no common source. If there is a symmetric spacetime interval between them it did not start with a zero length. Worse, what specifies it's slope?

The SSI might very well be a piece of the puzzle, indeed a critical piece, but with some others, it remains just a speculative idea, not testable, not falsifiable.

Paradigm has reason to worry about having to think out of two boxes at once.

Decoherence

Decoherence is the phenomenon where a quantum system becomes more and more classical as it continues to interact with its environment. The end point of this progression should be the act of measurement, but whether decoherence can make the entire journey on its own, or not, seems to be a matter of faith amongst physicists. Those with *measurement fatigue*, tend to grant it that status, others think it is just a precursor (a necessary one), but that there must still be some final step which yields a classical outcome. The metaphor of QT3 is a better fit with the later perspective. Semi-entanglements are a kind of decoherences, but true collapse does not happen until a cyclic entanglement occurs.

Note that cyclic entanglements in QT3 do not invoke spacelike causes, nor does QT3 have to worry about conjugate bases. So, while the toy universes are good for inspiration, it is not at all clear how to translate their core features into real physical systems. Contradiction and cyclic entanglement need to be anchored in reality, and that step is yet missing. The Realm retains its secrets.

Quantum Tic-Tac-Toe

Oh, the beauty of abstraction – and oh the pitfalls. Nine possible states, but only two-way weighted superpositions, equally weighted in fact, and without the use of complex coefficients. Only one base, no relativity. Objects (moves) are created out of thin air, no motion. Nothing that oscillates, no smooth unitary evolution. And no statistics, just a divide between *placement* moves and *collapse* moves, the first not deterministic, the second not statistical. Even though all 'X' marks are indistinguishable once on the classical board, and all 'O' moves are likewise indistinguishable, the game treats them as *distinguishable*.

As a toy universe it is woefully shy of key features. On the map from abstraction to reality there remain a lot of Terra Incognito landscapes.

Indistinguishable Particles

Given N particles each with M possible states, the Hilbert space is *vast*, it scales exponentially, M^N. If that is, the particles are distinguishable. When they are not, the Hilbert space gets radically reduced. In the current formulation of QM, the Hilbert space is specified by the physical situation and assumed fixed. All the math, all the linear operators, unitary or projection, are framed within this fixed mathematical space. Yet it is possible for a system to evolve in such a way that formally distinguishable particles become indistinguishable, and this appears to be a nonreversible transition.

The current literature is sparse on how to handle this. None of our toy universes address it either.

QTP/QTI

Do you like jigsaw puzzles? Ever mix 10 puzzles together? Didn't think so.

It is an elegant hypothesis, conceptually. In terms of details, however, there do not yet appear to be clear threads we can pull on to expose its internal structure. Like string theory, it presents a daunting number of permutations to explore but is far less mature.

So, the shut up and compute crowd may yet have the last laugh. But the strategy of make progress wherever you can, is a sound one. You might get lucky, the gestalt *Aha* moment may show up, the jungle crystalizing into an orchard – or not. All we can do is press forward, pluck the low hanging fruit, develop tools, concepts, jargon, make more and better toy universes – until something gives; or until we give up.

What would success look like? A testable specification of how an isolated quantum system – isolated yet nonlocal – can, under strictly unitary evolution, find itself in a state that cannot be expressed in all bases.

It is a strange time to pursue a breakthrough in fundamental physics.

Table of QTP Objections

Paradigm's quest may be more difficult, lengthy and subtle than he anticipated.

Time to update our con table. This replaces Dogma's original list.

Table of Objections to QTP – version 2.0		
Item	**Label**	**Description**
1	Temporal Paradox	Spacelike causes imply FTL, but also time travel; the problem is how to avoid the Grandfather Paradox, that is, how to avoid a causal contradiction in time.
2	Relativistic Consistency	Given two events connected by a spacelike cause, it must be possible for all observers to determine which event is the cause and which the effect. Partial success, works for photons.
3	Randomness	Entanglement demonstrates nonlocal correlations, but the random outcome of measurements prevents sending a signal; what is correlated is noise, not signal.
4	Falsifiability	It must be possible to devise experiments with the potential to falsify the hypothesis.
5	FTL by Measurement	Falsified – dead end.
6	SSI for matter particles	Can center of mass as a privileged frame be extended to include matter particles?

7	Synchronizing noise	Can twin random streams be correlated, positively or negatively?
8	Causality visa-vis correlations	Ripe area for hidden assumptions. Can we model a taxonomy of correlations?
9	Semi-entanglement	Are there physical systems that demonstrate semi-entanglements; systems where the particles are non-separable, but less than a full EPR style entanglement?
10	Entangling foreign particles	Is it possible to entangle particles that have never met before?
11	Extending entanglements	Can a semi-entanglement be extended?
12	Cyclic entanglements	Interesting concept, but is it too fuzzy? Are SSI and relativity required? Where do imaginary truthvalues enter?
13	Decoherence	Any role for this concept? Can any of our metaphors model it?
14	Imaginary truthvalues	Can we formalize them? How do they connect with conjugate bases?