The Paradigm Discourses

"All You Zombies"

Once you've eliminated the impossible...

Logic took the lead to summarize; "A magic-envelope opened horizontally only reveals gold or silver coins, and one opened vertically only reveals platinum or osmium coins. A horizontal opening will not change a classical coin if it is gold or silver, but it will convert platinum and osmium coins into gold and silver ones and do so completely randomly. Similarly, a vertical opening will not change a classical coin if it is platinum or osmium, but it will convert gold and silver coins into platinum and osmium ones and do so completely randomly. It's a lot like Reason's uncertainty box, how one chooses to observe affects what kinds of values are possible."

Experiment extended the summary, "Apparently, spooky-coins get converted to classical coins randomly as well, but in an anti-correlated way."

Theory, "Now we are left with the conundrum, explaining how this comes about. It seems that opening one envelope of an EPR pair must cause the other coin to collapse from spooky status to classical status. The question is which one?"

Curiosity, "No matter how far apart they are?"

"No, no, no, no, no. You're all nuts." Dogma stammered. "You cannot have that kind of causality. If opening an envelope on one side of the realm causes an entangled envelope on the other side of the realm to open, then you are talking about faster than letter causality."

Curiosity, "Yes, perhaps so, but letters are *so* slow. FTL would be a cool, and useful achievement."

Reason, carefully, "Yet, we just saw – witnessed would be more accurate, that for SCME, neither timelike nor common cause suffice to explain the data." Experiment nodded in agreement adding, "We just showed those explanations to be impossible."

Paradigm, "You know I hate to quote fictional characters, but didn't the great Sherlock Holmes say that once you've eliminated the impossible, whatever remains, however improbable, must be the truth?" Understanding lifted his eyes from his latest book; it took all his will power not to laugh at that one.

Dogma, "Then we've missed something. There must be some way that information is encoded in the spooky coins that explains the correlation. We'll just have to look for it, look for it very carefully, because it appears like it is well hidden."

Dogma pressed on, "There are only two types of causality, timelike cause or common cause. Every cause has an effect, and every effect has a cause. More importantly, the cause always, *always* mind you, comes before the effect. And," catching his breath, "effects don't cause causes. QED."

Dogma was so distraught he was beginning to salivate, but before he could muster another outrage, the dinner bell rang. Genteel banter on more mundane matters passed the time as the meal was consumed.

It was Curiosity who resumed the conversation interrupted by dinner, “How sure are we that there are only two kinds of causes?”

“Well,” Theory stalled to martial his thoughts, “before relativity, there were only two, but after relativity we recognized that at least formally, a third kind of cause, spacelike causality could be defined. However, it has never been observed,” Experiment nodded, “and worse it is plagued with consistency difficulties.”

Dogma, “Don’t go there, don’t even think about going there. You know it is impossible, the objections are innumerable and insurmountable; breaking letter speed breaks physics. Again QED.”

Paradigm looked up, “I don’t like limits.” They ignored him.

Dogma pressed his momentum, “Let me list them…”

“FTL travel requires infinite energy,” one finger up.

“Observers can’t agree on which event is cause, and which effect,” another finger.

“Can’t isolate experiments; the rest of the realm might be entangled, there goes reductionism,” a third finger.

“If you try to use quantum entanglement, randomness masks any signal,” now four fingers.

“Some observers will see the causality going backwards in time,” this time the other hand went up, he was running out of fingers.

In the brief lull, Curiosity got a word in edgewise, “On the other hand…” Dogma glared at her, “you have different fingers.”

After a little light laughter, Proof chimed in, “I have to agree with Dogma on this one…”

“Don’t interrupt me,” staring them all down, “I’ve saved the best for last; FTL means time travel, and that means paradox. It doesn’t just break physics; it breaks the whole damn realm. It’s not just physically impossible, it’s *logically* impossible.” Dogma paused to catch his breath.

For a moment all was silent, it was a compelling list. Cocking her head to one side, Curiosity inquired, “I think you’re going to have to explain that last one to me. How can being able to communicate instantly lead to time travel?

Dogma, “Well, not *travel* so much, but temporal communication, if quantum entanglement were to support spacelike causality it would allow information to be sent into the past.”

“I still don’t see.”

Theory injected, “Instantaneous is not a relativistic invariant.”

Mathematics went to the board and drew a pair of dotted lines at opposite 45-degree angles to the vertical, framing an inverted triangle. “Let this be a standard spacetime diagram; time up, space sidewise. These dotted lines are the light cone,” he paused, “not sure why the name, but they are the world lines that letters follow. Time will be measured in s-units, distance in ls-units.”

Next, Mathematics drew a horizontal line within the light cone, marking each end as an event. “This horizontal line represents instantaneous, but to an observer in motion,” he drew a second line with a slight slope crossing the first one, “that observer sees one event before the other,” and now drawing a third line, sloped in the other direction, “and an observer moving in the reverse

direction sees the events in opposite order. Simultaneity is not preserved, they have no way to define instantaneous in a consistent way, they can't agree on which event is first, thus they cannot agree on which event is the cause and which the effect.

"No, but they can agree on which event is on the left and which is on the right." Reason said. "For timelike events first and last are invariants, but for spacelike events left and right are the invariants." Continuing his train of thought, "Theory is right, the question for spacelike causality is which event is the cause, the one on the left or the one on the right. If you can resolve that without appealing to past or future, for even one observer, then all the others will agree. That could work."

Proof, "I think I can clarify. To get time travel," Dogma glared, Proof adjusted, "Ahem, I mean to get temporal communication with quantum entanglement we need two spacelike causes, one left to right, the other right to left. The physical systems that produce such causes must be in rapid motion in opposite directions. Let the left-right system be moving left, so that from the lab frame the information is traveling backwards in time, while also going to the right. Let the right-left system be moving to the right, so that in the lab frame the information is still traveling backwards in time, while also going to the left. Time the communications so that the right sides are co-located when the information arrives down the first leg (left to right). It is then simply passed down the second leg (right to left). Sender on the left (later in time) echoer on the far right, receiver on the left (earlier in time) gets the message before it was sent."

Mathematics still at the board, erased his sloped lines but kept the light cone, and drew a long thin triangle pointing to the right, and reiterated Proof's explanation, "At the top apex, the information is sent to the right, it is echoed at the far right apex, now traveling left, received at the third apex, directly below the first." He retraced the flow with his finger, "Spacelike to the right, spacelike to the left, both backwards in time, timelike from receiving to sending. Message received before sent."

"And that," Dogma insisted, using a finger now to point out the obvious, "is the problem. What if the numbskull on the left changes his mind and sends something other than what was received, a different message? Paradox. Breaks the realm."

Logic, "And that is the basic causality paradox. It is a logical impossibility, even before it is a physical impossibility. Reality disappears in a puff of, *dare I say it*, logic." He was grinning.

Understanding put his book down, strode over and stood in front of Paradigm. The tableau lasted for several seconds. Finally, Paradigm broke, "Why are you looking at me?"

Understanding, "That triangle that Mathematics drew, the one showing how two spacelike causes can support sending information into the past," Paradigm, following along but only nodding, "let just one bit be sent, let the 'numbskull,' to quote Dogma, have only two choices: echo or invert. Now where, or perhaps when, is the cause of that bit taking on a definitive value?"

Before Paradigm could respond, Curiosity interjected, "The cause isn't localized, there is no place on that triangle, no place on that loop, that is unique." She looked around at all of them, "The cause is not an event, not a point like event anyway; it is nonlocal, isn't it?"

Reason, “Well without a point cause, I suppose a random value would be the most plausible outcome.”

Logic, “But we are forgetting Dogma’s strongest argument against this being possible at all; if the ‘numbskull’ chooses to invert, then there is a causal contradiction, a paradox.”

Paradigm stood up, “But only if we are presuming Boolean truthvalues. When the numbskull inverts, the loop will be paradoxical in the Boolean basis, but indeterminate in the imaginary basis. When he echoes, the loop will be paradoxical in the imaginary basis, but indeterminate in the Boolean basis.”

Curiosity, “Does nature have a way of always avoiding a paradox?”

Theory, “Are you proposing that imaginary truthvalues are a loophole in the temporal paradox argument against time travel?”

Experiment, “*Loop*-hole, Theory, really?” He pointed at the diagram on the white board and made a circular motion. Theory smiled, then both pointedly looked at Paradigm. “Nice pun, boys, I missed it. Next time.

“But no, I think I’m about to propose something bigger; the loop collapses in the basis in which the truthvalues are indeterminate. What if,” he paused a moment to gather thoughts still forming, “a closed causal loop, at the quantum level, is paradoxical in all bases but one. In one and only one basis is it indeterminate. This would offer a mechanism for choosing the basis, or more accurately, how nature choses the basis. There are always two possible truthvalues in the collapse basis, so there is a mechanism for the randomness of quantum systems. The conditions for collapse are objective, no reason to invoke mysterious and ill-defined concepts like consciousness. It would resolve the interpretation issues. We have an explanation for how an isolated quantum system can make the transition to a classical state without having to invoke a ‘classical’ system to measure it. And yes, to Theory’s question, it would permit spacelike causality while prohibiting temporal paradox. Can it be that a self-referentially entangled quantum system self-collapses?”

He made eye contact around the group. “Do we have a candidate solution to the quantum measurement problem?”

Theory, “That’s starting to sound like a real hypothesis.”

Experiment, “Can we test this?”

Reason, “It would introduce nonlinearity into the system in a natural way.”

Proof, “You’ll want to give it a name.”

Paradigm, “I’m thinking Quantum Temporal Paradox, QTP for short.”

Curiosity, “Wouldn’t it be more accurate to call it quantum temporal indeterminacy?”

Logic, “Maybe, but it’s not as catchy.”

Reason, “Stick with QTP, QTI is a nonstarter. We,” he looked around the group, “do not want to be the team that proposes a theory that would be pronounced ‘cutie,’ we’d never hear the end of it.”

Mathematics, “Thus, what our numbskull has actually done is gotten the loop to measure itself.”

Paradigm looked at Dogma, who looked a little pale, “You’ve a long list of objections to spacelike causality.”

“And I’ll hold you to every one of them.”

Understanding grinning, almost glowing, “Well, then; looks like you all have a quest.”