What it is: Smoking gun proof *falsifying* "materialism explains all"



What it is not: Support for any fanciful claim about connectedness

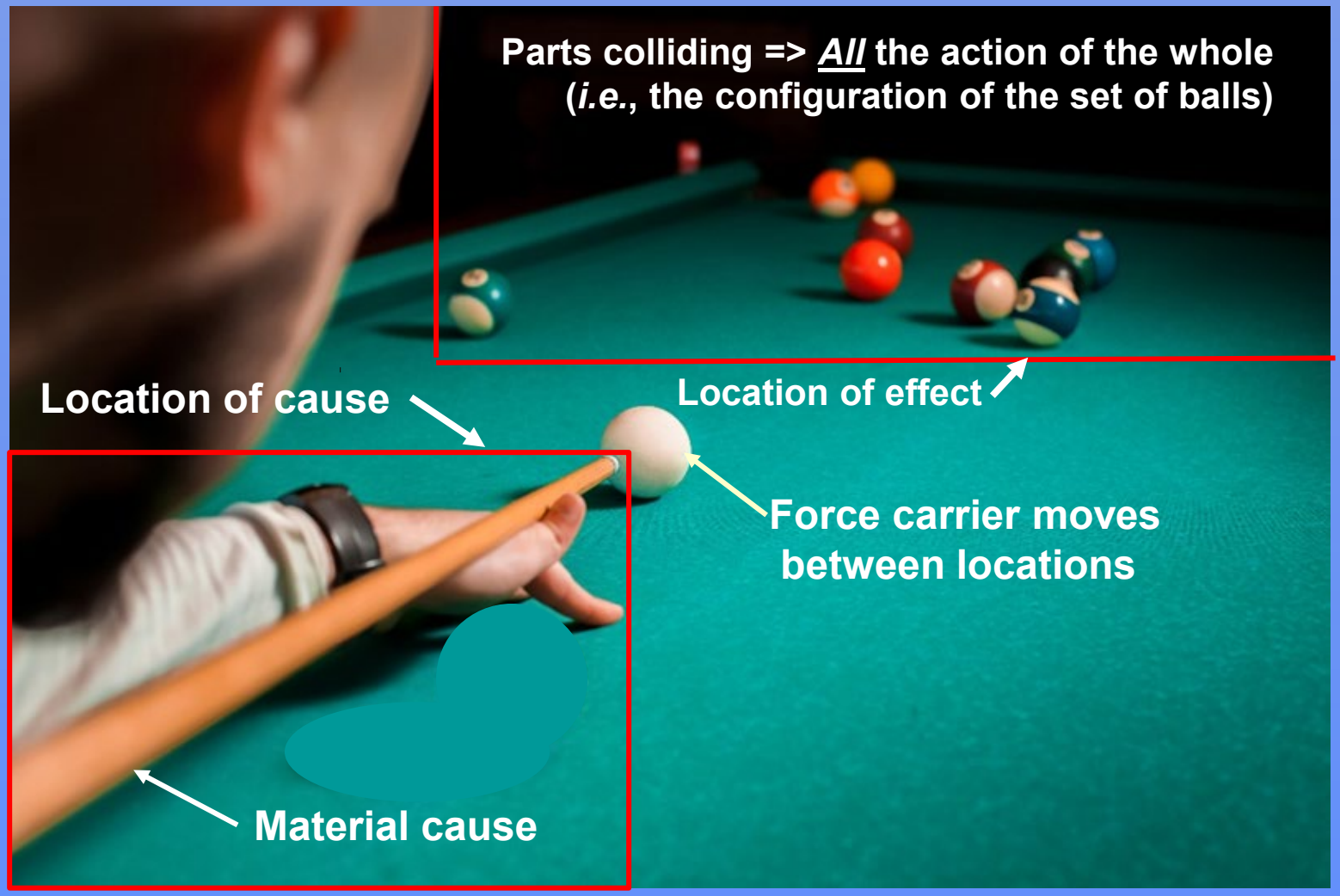
What entanglement is and is not

Prepared for The Science of Consciousness 2026

October 14, 2026 San Diego CA

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Materialism: Interaction of its parts entails *all* the action of *any* whole[1]

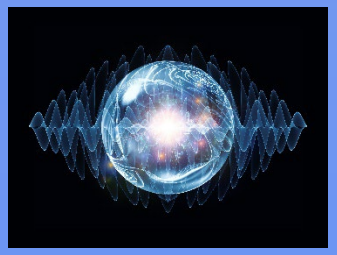


Local: Cause and effect are in separate locations[2]

Locality is *independent of extent* of distance between cause and effect



An electron falls an energy level in an atom in Andromeda

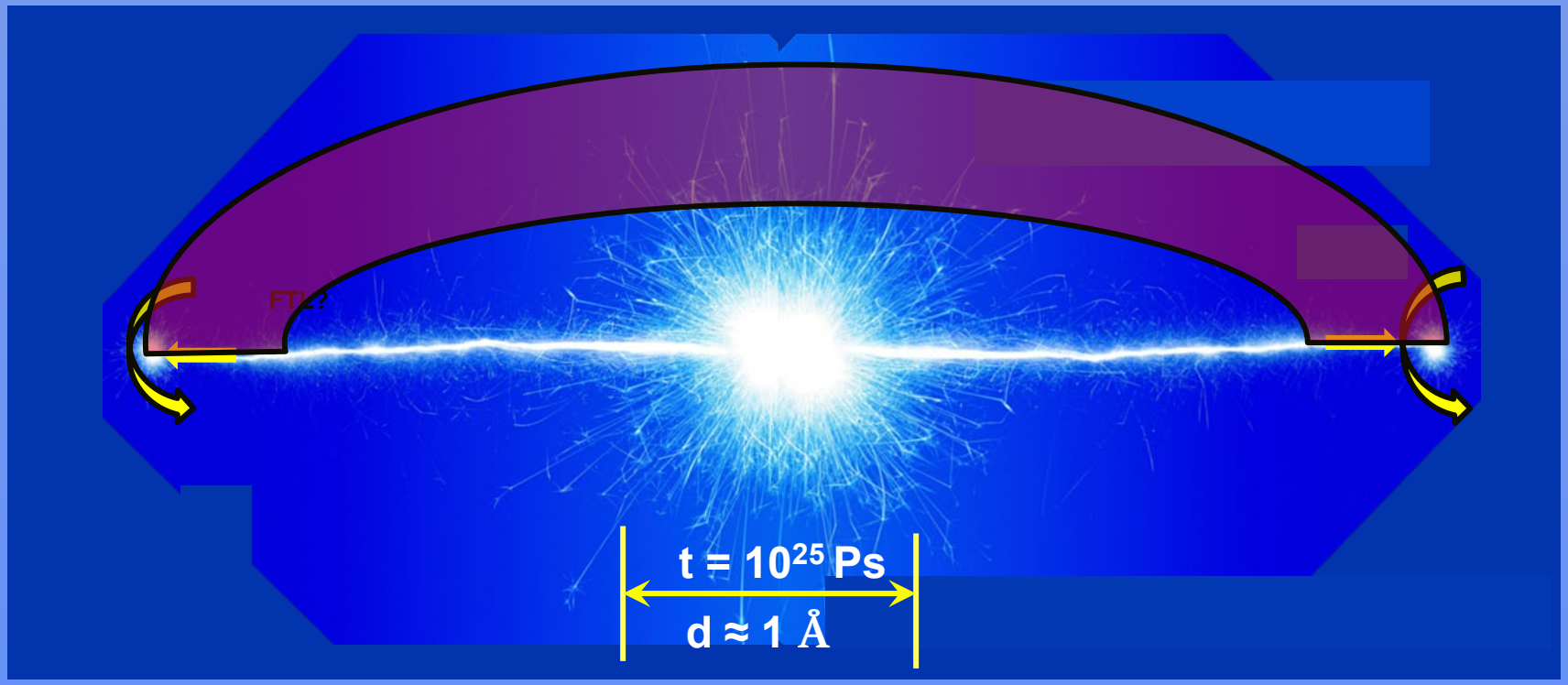


A force carrier flies unimpeded for 2.5 M years at v=c



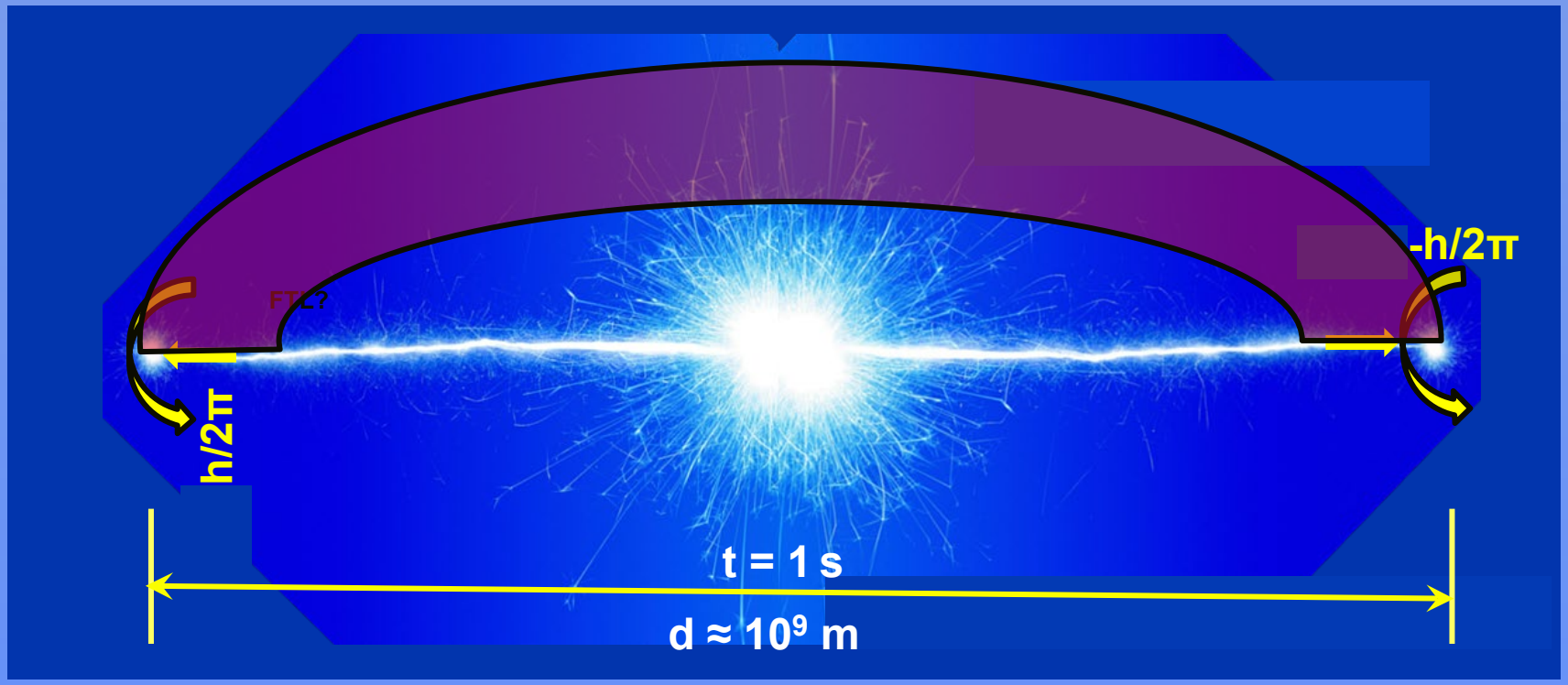
An electron rises an energy level in an atom on Earth

Remarkably, non-locality can work at extremely short distances



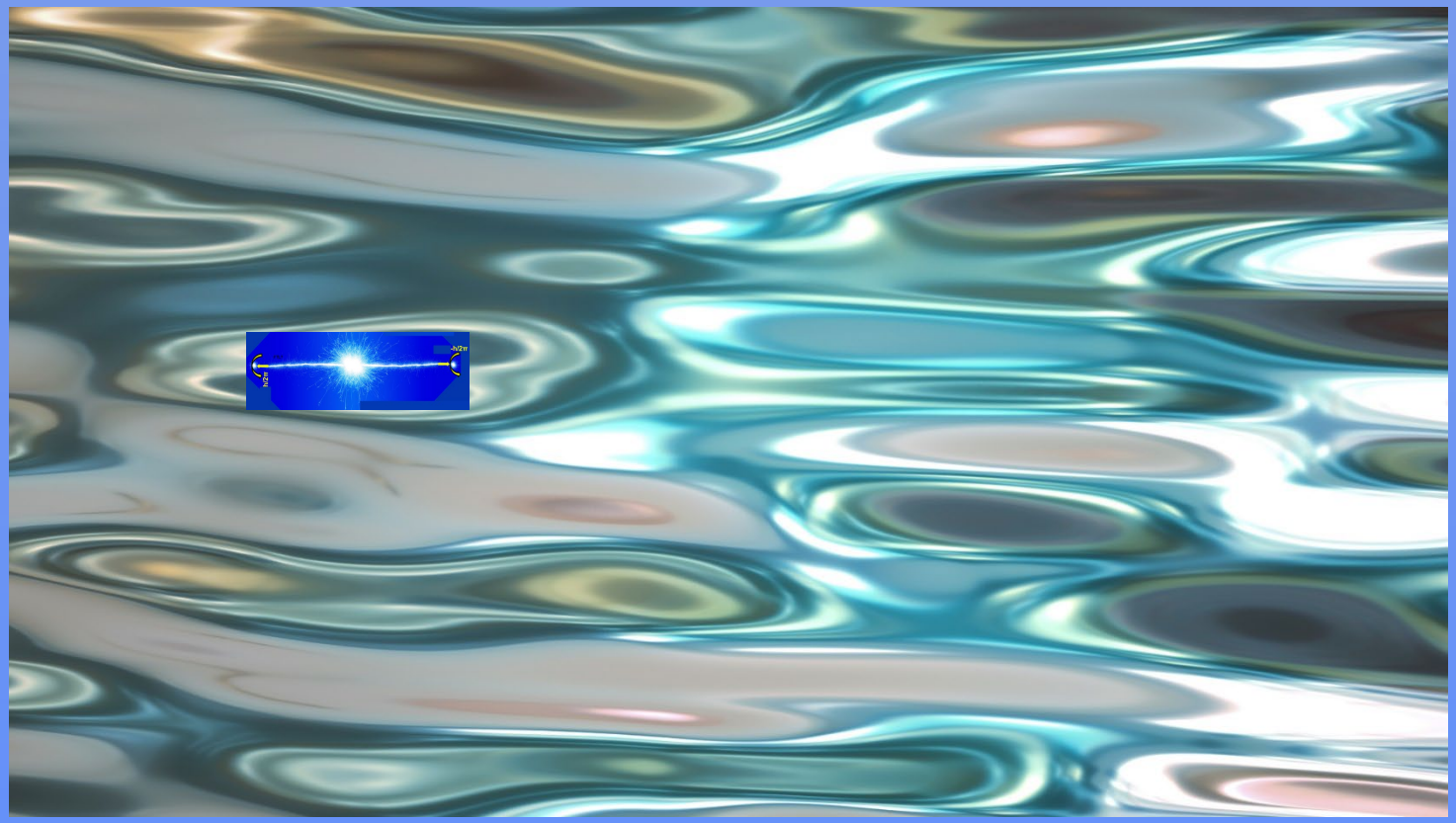
By the first 10^{25} Planck-sec of its life, the extent of the whole has not yet exceeded *the extent* of the atom that gave it birth

Photon entanglement *is* *not* an instance to two photons flying apart[3]



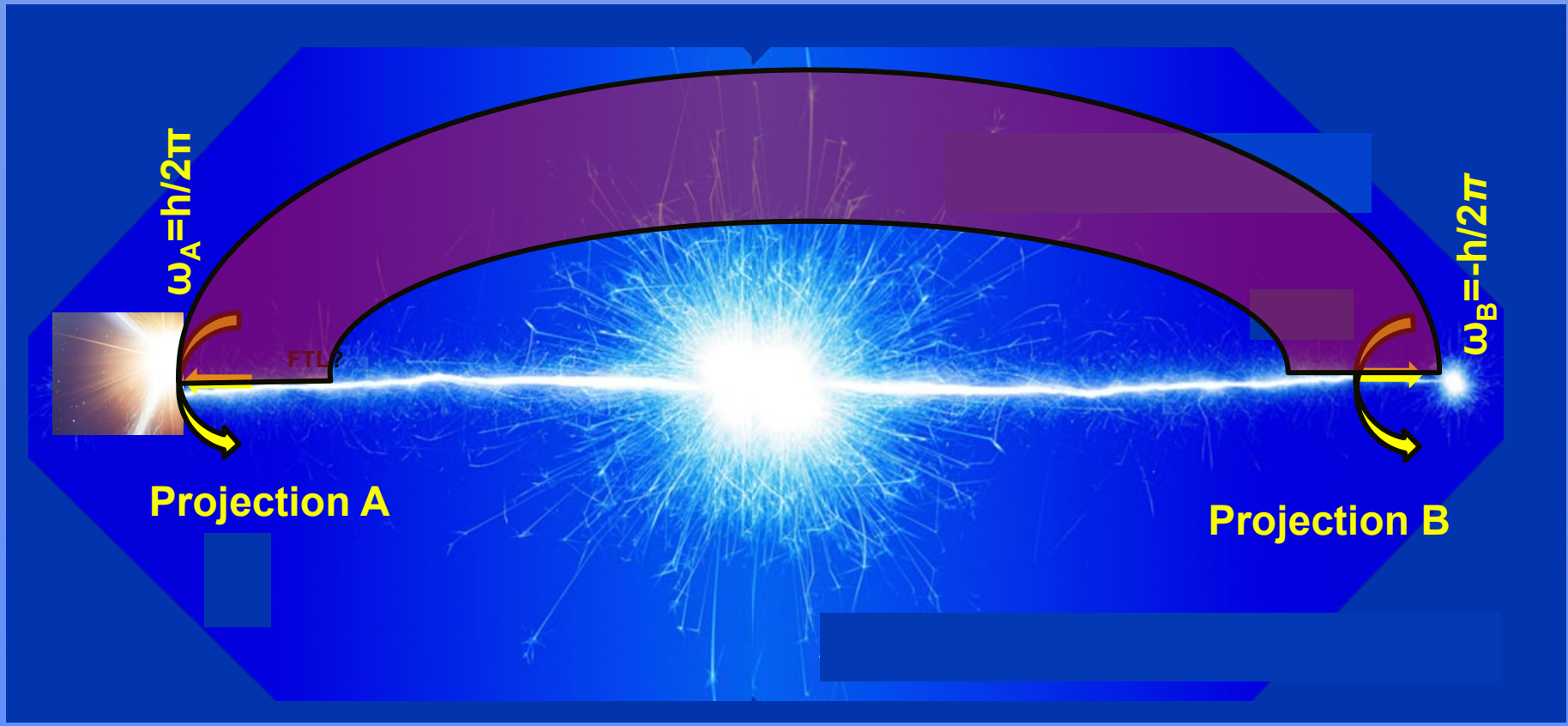
An "entangled pair" is a *single* *indivisible* *whole* process increasing its spatial extent at the speed of light

That whole is inside a container for which *identity*, not distance, imparts distinction from other containers[4,5,6]



The container provides external constraint on the action of its contents; *non-local*: the influence of the external constraint permeates the contents; contents are further constrained by internal constraints (*e.g.*, $d^2=x^2+y^2+z^2-c^2t^2$)

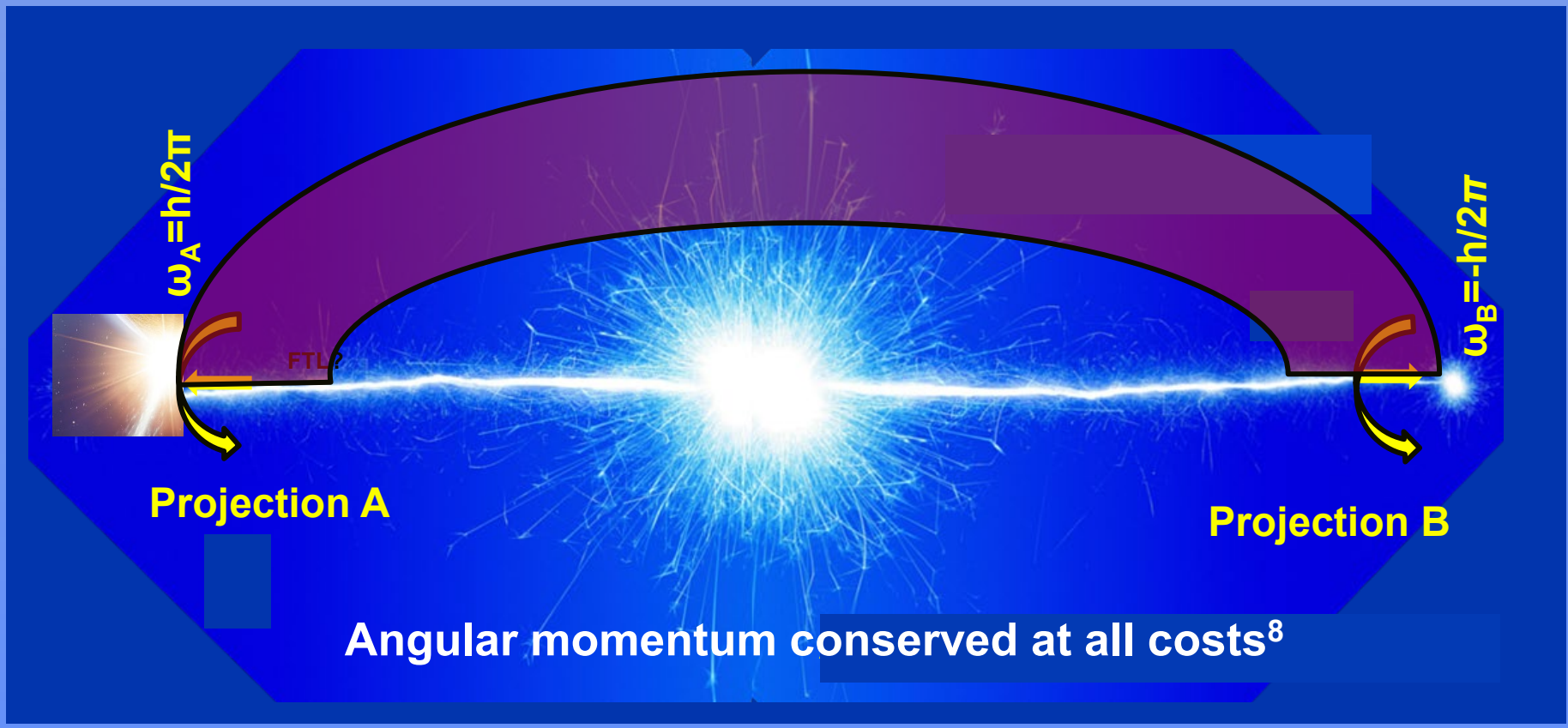
The entailed effect of non-local cause projects onto multiple locations in the space-time continuum[7]



Signature of non-locality: Action of the content is *instantaneous* throughout its extent[7]



If any aspect of the content encounters a disruption …



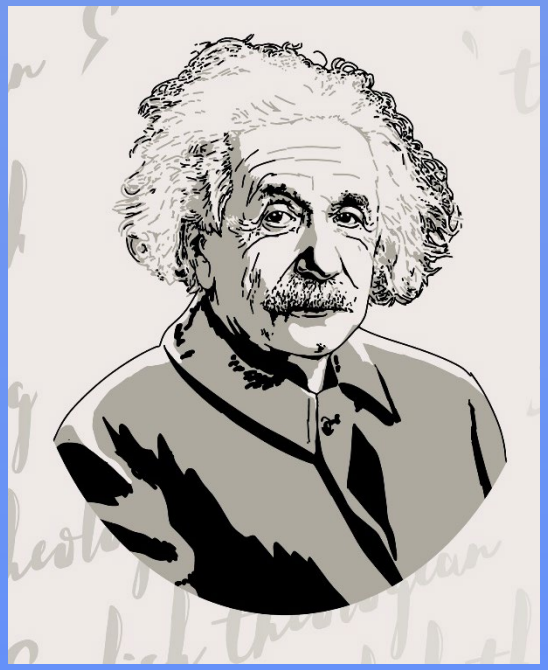
… the entire process immediately experiences the hit, and not just the projected “part”

Quantum mechanical "wave functions" describe *the effect* of instantaneous correlation, but …



… what do they say about *the cause*? Spoiler: Nothing!

Einstein's definition of complete: "Every element of the physical *reality* must have a counterpart in the physical *theory*."[7]



EPR showed that *ψ* *excludes* description of cause of correlation

The *workhorse* of QM *is the* probability density function $p = (\psi^*\psi)$

Imagine flipping two independent coins

P
P



Calculate $p_{\$}$(heads)
Given $p_{\$}$(heads), calculate the probability that $ lands "heads?"



Calculate from $p_{€}$(heads)
Given $p_{€}$(heads), calculate the probability that € lands "heads?"

How does one find the probability of *both* coins landing "heads?"



$p_{\$}$(heads)



$p_{€}$(heads)

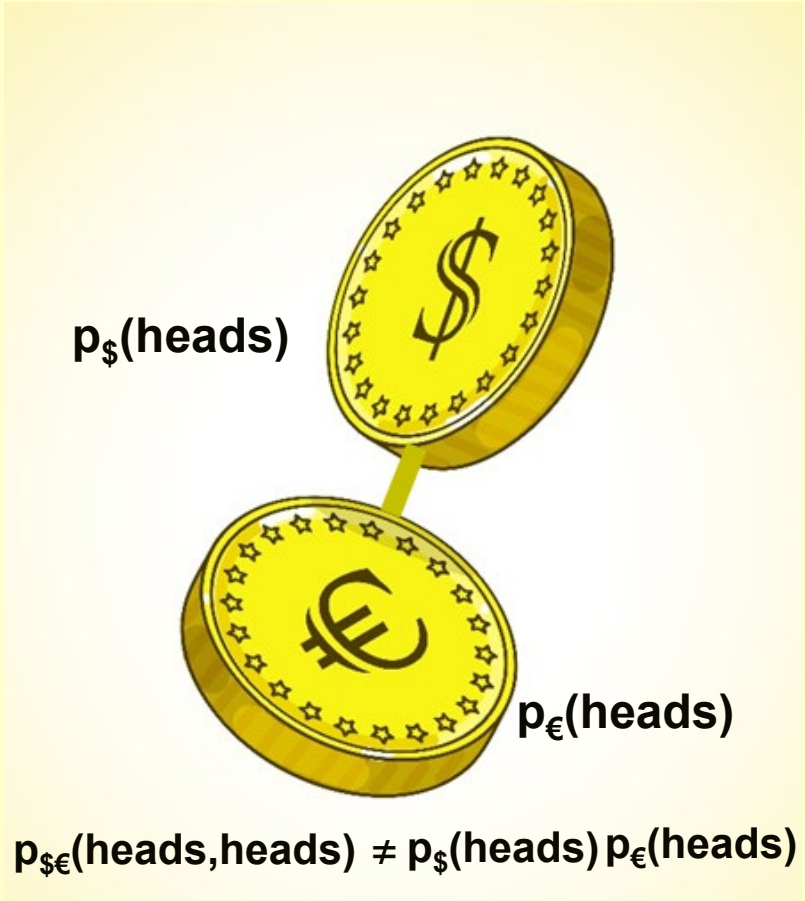
Presuming **that the action of *neither* coin affects the action of the other:**

$$p_{\$€}(\text{heads,heads}) = p_{\$}(\text{heads})\, p_{€}(\text{heads})$$

Independent factors

Calculate probability from this *joint* probability density function

What if the action of *either* coin *does affect* the action of the other?



Joint probability density function *cannot* be factored

Necessary condition for entanglement **is that the joint probability density function *cannot be factored* into independent densities[9]**

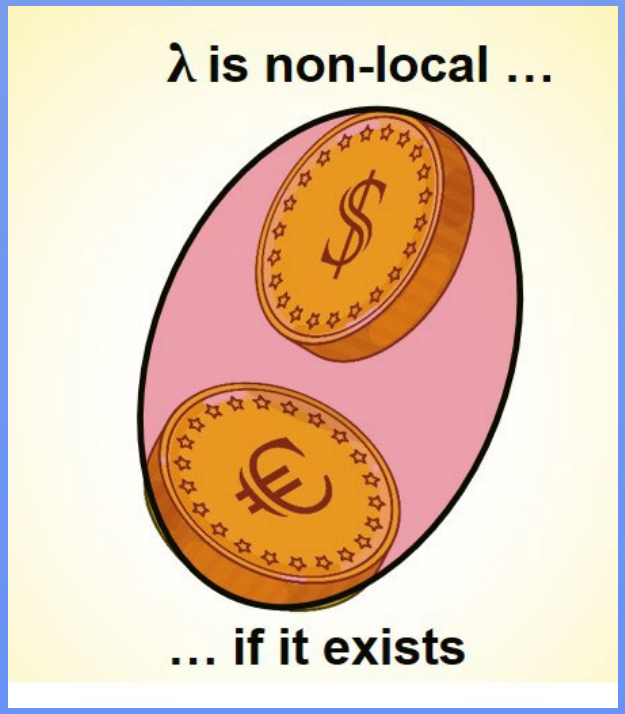
A rigorous appeal to entanglement requires that the "entanglement" actually has an unfactorable ψ



- Typical ***unjustified*** claims
  - Everything is entangled with everything else
  - Non-locality defies human description
  - Bohm: Pilot wave provides universal interconnection

We have a criterion for the *effect*; what can we say about the *cause*?

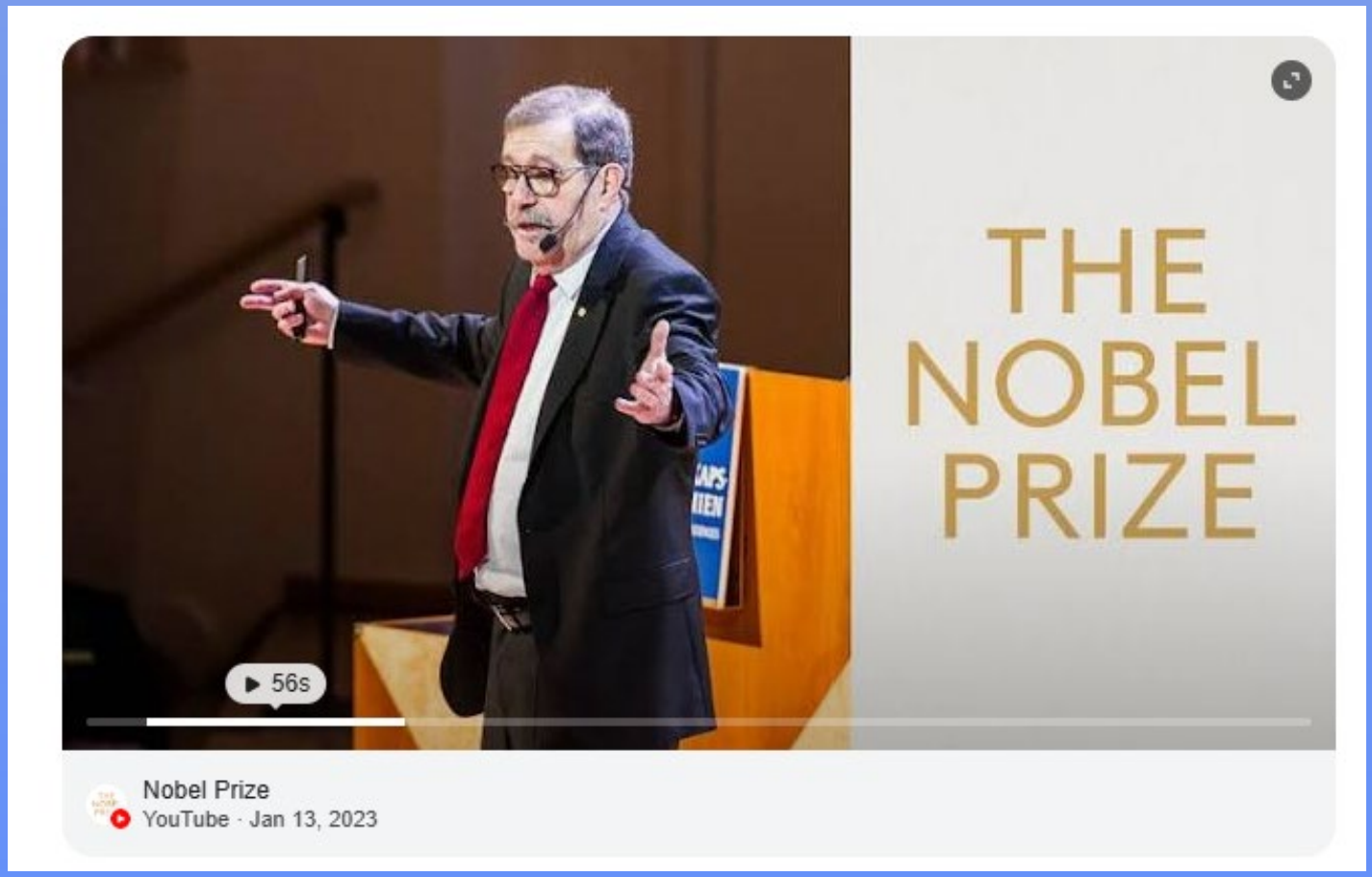
Bell proved by contradiction that …





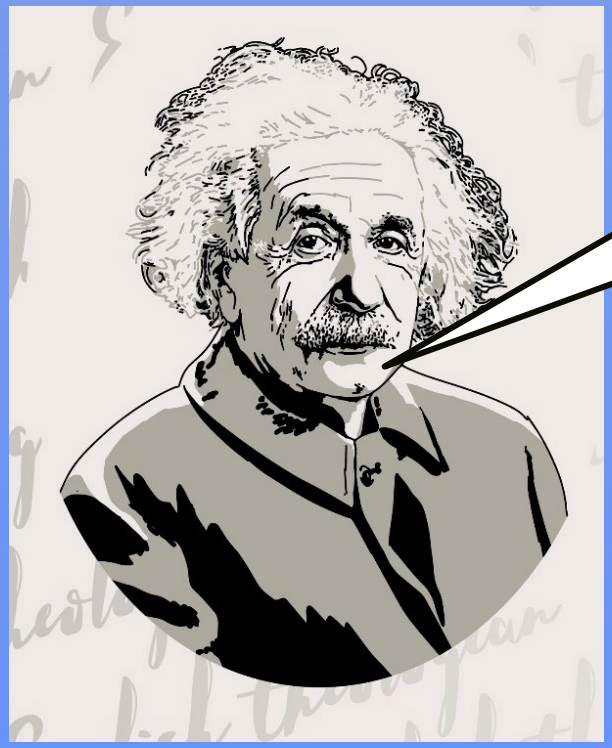
… a local hidden variable describing cause of correlation ***does not exist***; Bell neither forbids nor requires a non-local hidden variable[10]; can we justify the existence of a hidden non-local variable?

Aspect observed the predicted *effect* in reality[11]



Instantaneous correlation => No force carriers
No force carriers => Cause cannot be local

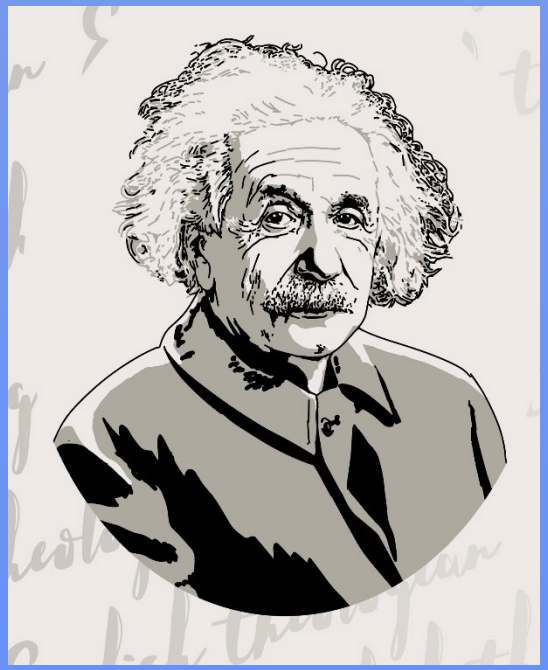
Aspect's results could not happen in the absence of non-local cause



There is no effect without a cause, and there is no lawlessness in creation[12]

Orthodox science dismisses Einstein's claim as naively archaic but, there is another name for an uncaused effect: It's a miracle!

“Every element of the physical *reality* must have a counterpart in the physical *theory*.”[7]



By this standard, a complete description of entanglement would require a non-local variable corresponding the non-local cause

The punchline: Materialist axioms forbid non-locality,[1] but a non-locally caused event has been observed



This counterexample *falsifies* the materialist claim that *every* event in reality is the cumulative effect of interacting material parts

Logical Foundations

Materialism is an ontological description of ultimate reality. It is most effectively described as a set of propositions that follow logically from the following axioms

A1. Every event in reality is the cumulative result of the interactions of constituent particles

A2. Laplace's Demon is a complete (in principle) description of the action of reality, including the following particulars:
The state of reality is static, consisting of the position and velocity of every particle in reality at a given instant in time.
The state of reality at a given instant is the entailed effect of the state of reality at the immediate past instant.
The state of reality at a given instant is the cause of the state of reality at the immediate future instant.
The transition between states is governed by constraints characterized as "Laws of Nature."
The state transition can be fully described by a sufficiently elaborate equation of motion.

A3. All action at a distance is local, specifically:
The causal event is in a bounded location
The entailed effect is in a different bounded location
Action at a distance is carried from cause to effect by force carriers

C1. Ontological ambiguity does not exist; for each state of reality one and only one subsequent state is possible.
C2. Since every state is correlated with its predecessor and successor, there is no ontological randomness

A4. Only reports of independently repeatable third-person experience are admissible for consideration by the ontology founded on these axioms

Reductionism is an epistemological description of the description of ultimate reality. It is based on the following axioms

A1. Every event in reality can be completely mapped to a set of variables, each of whose domains is R^n.

A2. Every "Law of Nature" can be described by a function, $f: X \rightarrow Y, X = R^n, Y = R^n$.

A3. Every state transition can be fully described by an equation of motion.

C1. The equation of motion describing all of reality can be completely described by a sufficiently complicated Turing machine
C2. Epistemological ambiguity is forbidden
C3. Nested self references (*e.g.,* $\Omega=\{\Omega\}$) are irreducible and ambiguous, hence forbidden
C4. In the absence of a complete description of the current state variable and equation of motion, the predicted next state is an estimate
C5. Probability is purely epistemological, an estimate of how far the expected future statemight depart from the eventual observed future state

References

1. "The secret of life is that it is made of parts that are not alive. Every cell in your body is a mindless little mechanism, a robot. And you are a trillion-robot team. There is no 'you' inside controlling them; 'you' are the result, the emergent effect, of the cumulative interaction of all those clueless little parts."— Dennett, *Bacteria to Bach and Back: The Evolution of Minds* (2017)

It is worth mentioning that the concept of emergence in materialism is qualified. Carroll, *The Big Picture* (2016), p.107 raises four questions about emergence. The first three involve large scale events that are directly derivable from the cumulative effects of particle interactions. Concerning these three, he comments, "So far we've been discussing 'weak emergence:' even if the emergent theory gives you a new understanding and an enormous increase in practicality in terms of calculations, in principle, you could put the microscopic theory on a computer and simulate it, thereby finding exactly how the system would behave. (p. 108), Concerning his fourth question he says "In strong emergence – if such a thing actually exists – that wouldn't be possible. When many parts come together to make a whole, in this view, not only should we be on the lookout for *new knowledge* in the form of better ways to describe the system, but we should contemplate *new behavior*. In strong emergence, the behavior of a system with many parts is not reducible to the aggregate behavior of all those parts, even in principle." (pp. 108-9) To account for strong emergence, he says "The only way to think of it is as an effect of the whole on the individual parts." (p. 109) Within the materialist paradigm he says that strong emergence is impossible from the get-go. "There is no ambiguity in what an atom is supposed to do." (p. 109) The absence of the emergence of novelty within the bounds of materialism is consistent with Carroll's claim that "conservation of information" (p. 33) ranks along conservation of momentum as a fundamental principle of the natural world. He sees that claim as a direct consequence of Laplace's Demon.

2. Another axiom of materialism is that all action is local. "Locality evolved out of the field theories of classical physics. The idea is that for a cause at one point to have an effect at another point, something in the space between those points must mediate the action. To exert an influence, something, such as a wave or particle, must travel through the space between the two points, carrying the influence. https://en.wikipedia.org/wiki/Principle_of_locality" Accessed 9/29/2026

"Quantum Field Theory (QFT) and the Microcausality Condition• The Reference: Standard texts like Weinberg's "The Quantum Theory of Fields" or Peskin & Schroeder's "An Introduction to Quantum Field Theory".• The Core Principle: In QFT, local causality is strictly enforced by the microcausality condition. This mathematical rule dictates that the operators for two physical observables, must commute if they are evaluated at points x and y that are spacelike separated. The Logic: This means a measurement at point x cannot causally affect a measurement at point y if they are separated by space in such a way that light hasn't had time to travel between them. A cause can only ripple outward across space over time, creating a physical separation between the origin of the force and its destination." *Google AI mode* accessed 10/6/2026

3. Schrödinger, E. (1935). "Discussion of Probability Relations between Separated Systems, *Proceedings of the Cambridge Philosophical Society*, 31, 555-563. Speaking of the entangled pair, Schrödinger commented, "they can no longer be described in the same way as before, *viz*. by endowing each of them with a representative [state] of its own. They lose their individual states and share a single joint state."

4. Hofstadter, D,. *I am a strange Loop* (2007), p. 131, "A 'bare' strange loop of selfhood does not give rise to a distinct self — it is just a generic, vanilla shell that requires contact with something else in the world in order to start acquiring a distinctive identity, a distinctive 'I'."

Rosen, R., Essays on Life itself (1999), Chapter 8, Note especially equation 8.6, in which Rosen associates identity with impredicativity. On p. 311, he associates identity with formal cause, the property that remains invariant as a process executes a transformation.

5. Kleene, S.C., *Introduction to Meta-Mathematics* (**13th** impression, 2000) p. 42, An impredicative process is defined by its relationship with itself, *e.g.*, $\Omega=\{\Omega\}$.

6. Aczel, P. (1988), *Non-Well-Founded Sets*. Aczel proves the existence, uniqueness and logical coherence of the prototypical hyperset, *i.e.*, that which solves Ω={Ω}. Ω describes event that contains itself within itself, and is the logical primitive from which a hyperset representation of impredicatives, *aka* incomputable processes, can be devised. A degenerate form, in which the self-reference is broken, yields the empty set, Φ = {}. Using nothing but repeated appeals to the empty set, von Neumann constructed his ordinals, the set theoretic interpretation of the natural numbers, from which the entire field of mathematics is constructed. At the current stage of development of logic, Ω is the most overarching primitive representation of the organization of reality of which we are aware,

7. Einstein, A., Podolsky, B., and Rosen, N. (1935). "Can Quantum-Mechanical Description of Physical Reality be Considered Complete?" Physical Review, 47(10), 777. . This is the famous paper where Einstein and his colleagues identified what he later called "spooky action at a distance" (*spukhafte Fernwirkung*). They argued that because quantum mechanics predicted instantaneous correlations between distant particles, the theory must be incomplete. Google AI mode. Accessed 10/6/2026.

8, Thompson, W.J. (2004), *Angular Momentum*. Section 1.3 shows that the fact that physical laws are independent of orientation in space implies that the conservation of angular momentum applies everywhere.

9 Miller, D. A. B. (2018), *Quantum Mechanics for Scientists and Engineers*,, p. 432

10. Bell, J. S. (1964). "On the Einstein Podolsky Rosen Paradox." *Physics Physique Fizika*, 1(3), 195. Bell proved mathematically that no local hidden variables (Einstein's preferred solution) could reproduce the instantaneous statistical correlations predicted by quantum mechanic
It is noteworthy that Bell shows the non-existence of λ, the hypothetical “local hidden variable,” from the probability density function characterizing the EPR pair by using the same integral that Jaynes uses ti eliminate “nuisance parameters.”

Bell, J.S. (2004), *Speakable and Unspeakable in Quantum Mechanics: Collected Papers on Quantum Philosophy.* Page 152 Note Equation 12

Jaynes, E.T. (2003*), Probability Theory: The Logic of Science,* Section 7.13, "Nuisance parameters as safety devices“ Note Equation 7.45
Bell’s equation 12 and Jaynes’ equation 7.45 are identical

11. Aspect, A., Dalibard, J., and Roger, G. (1982). "Experimental Test of Bell's Inequalities Using Time-Varying Analyzers." *Physical Review Letters*, 49(25), 1804. Aspect conducted the definitive early experiment demonstrating that these spatial correlations are truly non-local and occur faster than the speed of light can travel between the particles. This work (alongside tests by John Clauser and Anton Zeilinger) earned the 2022 Nobel Prize in Physics.

12. Hermanns, W. (1983), *Einstein and the Poet,* p. 59

13. Heisenberg, W. (1927), “Uber den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik,” *Zeitschrift fur Physik*, (43), pp. 172-198.
ausality. Alternative frameworks like Bohmian mechanics explicitly embrace non-local hidden variables, while other interpretations handle the correlation differently

14. These are results for Is instantaneous correlation a signature of non-locality?
AI Overview
Yes, instantaneous correlation between spatially separated systems is a signature of quantum non-locality, provided those correlations violate Bell's inequalities.
Why It Is a Signature of Non-Locality
Violation of Local Realism: According to Bell's theorem, if physical systems had pre-determined properties (realism) and could only be influenced by their immediate surroundings (locality), the statistical correlations between measurements on separated particles could not exceed a certain mathematical limit (Bell's inequality).

YouTube
·Sabine Hossenfelder

Experimental Proof: Landmark experiments—such as those by John Clauser, Alain Aspect, and Anton Zeilinger (awarded the 2022 Nobel Prize in Physics)—showed that entangled particles consistently break Bell's inequalities. This proves the correlations are stronger than any classical, locally mediated explanation can allow.

quantumphysics-consciousness.eu

Important Nuances
No Faster-Than-Light Communication: Even though the statistical correlations are instantaneous across space, quantum non-locality does not allow for the transmission of actual energy, signals, or useful information faster than light. The individual measurement outcomes on each end are fundamentally random (probabilistic), meaning Alice cannot use her measurement to send a deliberate message to Bob without a traditional local signal.

University of Bristol

Local vs. Non-Local Interpretations: Standard quantum mechanics obeys the "no-signaling condition" (making it empirically compatible with special relativity), yet it rejects Bell's notion of local local causality. Alternative frameworks like Bohmian mechanics explicitly embrace non-local hidden variables, while other interpretations handle the correlation differently. Accessed 10/8/2026

Supplemental slides excluded from the live presentation due to time limitations

EPR, "Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?" *Phys Rev* 47

- Description of whole = Σ Description of parts
- Inference must move from small to large
- ∃ a largest model isomorphic to *all* reality
  - Corollary: We can ignore ontology ≠ epistemology
- Reductionism is complete in principle
- Largest model is map $\sigma: R^m \rightarrow R^n$
- Chronicle of Reality: Sequence of state tensors



The foundation of reductionism

Quantum Mechanics: Solutions of $\hat{H}\Psi = E\Psi$
This is pure epistemology (Heisenberg, 1927)[13]

"Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?"

- **Properties** of whole = Σ properties of parts
- **Causation** only moves from small to large
- **Real events** are isomorphic to largest model
  - Corollary: We can ignore **ontology** ≠ epistemology
- **Materialism is complete**
- **Universe** sequentially rachets through static states
- **Causal non-ambiguity**: Prior config. ⇔ current config.

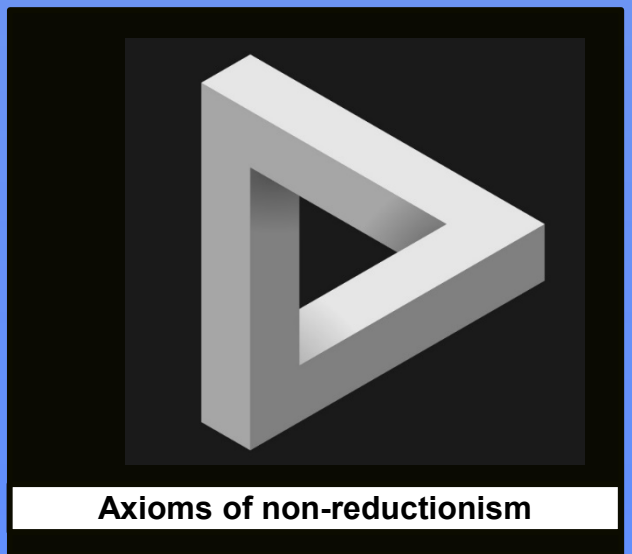


The foundation of materialism

Quantum Mechanics: Solutions of $\hat{H}\Psi = E\Psi$
This is pure epistemology (Heisenberg, 1927)[13]

Is there a larger theory of representation than reductionism?

- Description of whole > Σ Description of parts
- Inference moves both ways small ⇔ large
- ∃ no largest model of reality
- We must recognize ontology ≠ epistemology
- A descriptor may contain itself within itself
  - Ambiguous representation (*e.g.*, hypersets) is included
  - Break the loop: Impredicative becomes recursive



Axioms of non-reductionism

Is holism a rational ontology more inclusive than materialism?

- Everything is always moving all the time
- Action of whole > Σ Action of parts
- Inference moves both ways: small ⇔ large
- We must recognize ontology ≠ epistemology
- *Dynamic* constraint may contain itself within itself
  - Causally ambiguous constraint is included
  - Materialism: Limiting case of holism



What is it like to be a bat from the bat's point of view?

Representation of non-local influence is irreducible to numbers

$$\Omega = \{\Omega\}$$
$$\{\Omega\} = \{\{\Omega\}\}$$
$$\Omega = \{\{\Omega\}\}$$
$$\Omega \notin R^m$$

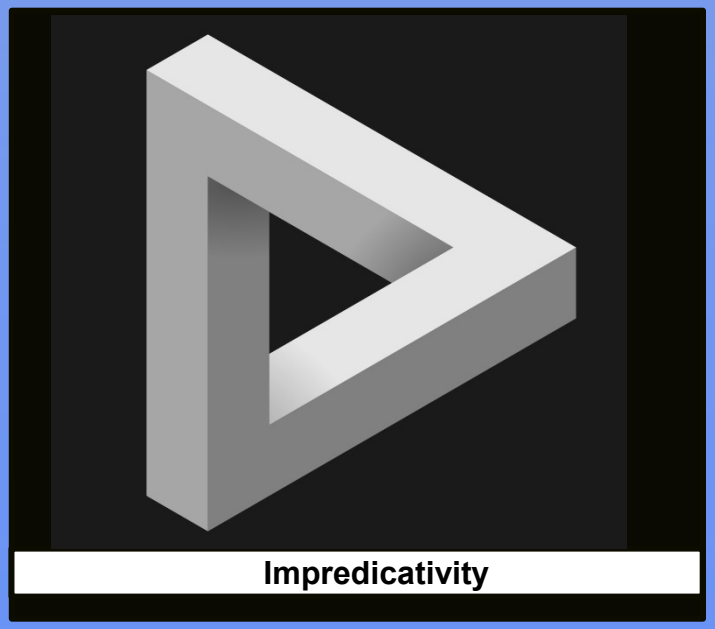
Inseparable: A dynamic process that contains itself within itself

Ambiguous, but non-contradictory

Ambiguity forbidden in Turing computation

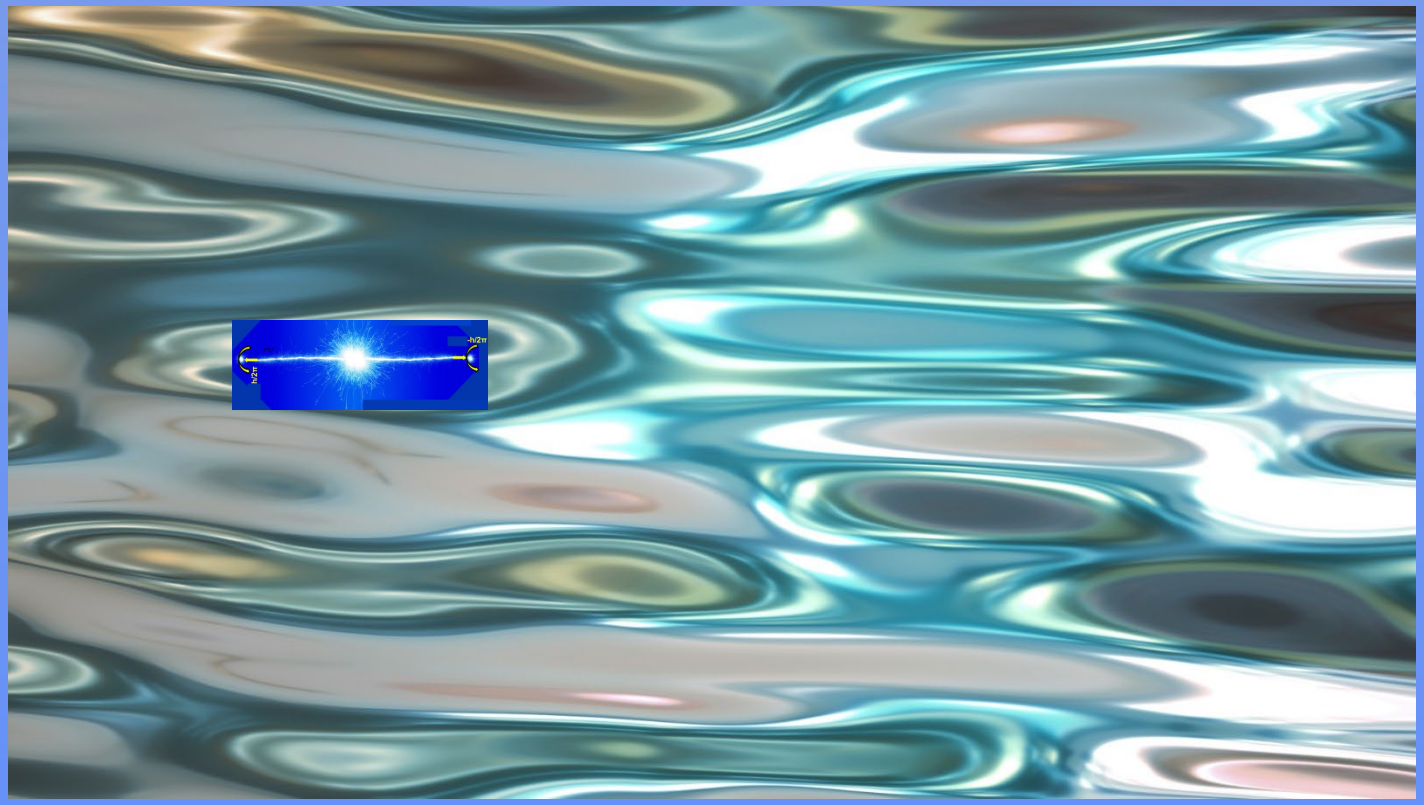
A non-local variable is necessarily *hidden* from any representation that is reducible to numbers

The geometry is unrealizable for static material objects, but …



… it is a non-contradictory, unique solution to Ω = {Ω}, and corresponds to ambiguous constraint (permits several possible non-identical outcomes); differs from randomness, the total absence of constraint

The influence the container imposes on its contents is independent of distance inside the contents[7]



Non-local: **The constraint on action imposed by the container is experienced *everywhere* *at* *once* within the contents**

Definition of *entanglement*: The wave function is unfactorable into wave functions of each part

Outcomes for *entangled* processes

$$|\Phi^-\rangle_{12} = \frac{1}{\sqrt{2}}\left(|H\rangle_1|H\rangle_2 - |V\rangle_1|V\rangle_2\right)$$

$$|\Psi^+\rangle_{12} = \frac{1}{\sqrt{2}}\left(|H\rangle_1|V\rangle_2 + |V\rangle_1|H\rangle_2\right)$$

$$|\Psi^-\rangle_{12} = \frac{1}{\sqrt{2}}\left(|H\rangle_1|V\rangle_2 - |V\rangle_1|H\rangle_2\right)$$

$$|\Phi^+\rangle_{12} = \frac{1}{\sqrt{2}}\left(|H\rangle_1|H\rangle_2 + |V\rangle_1|V\rangle_2\right)$$

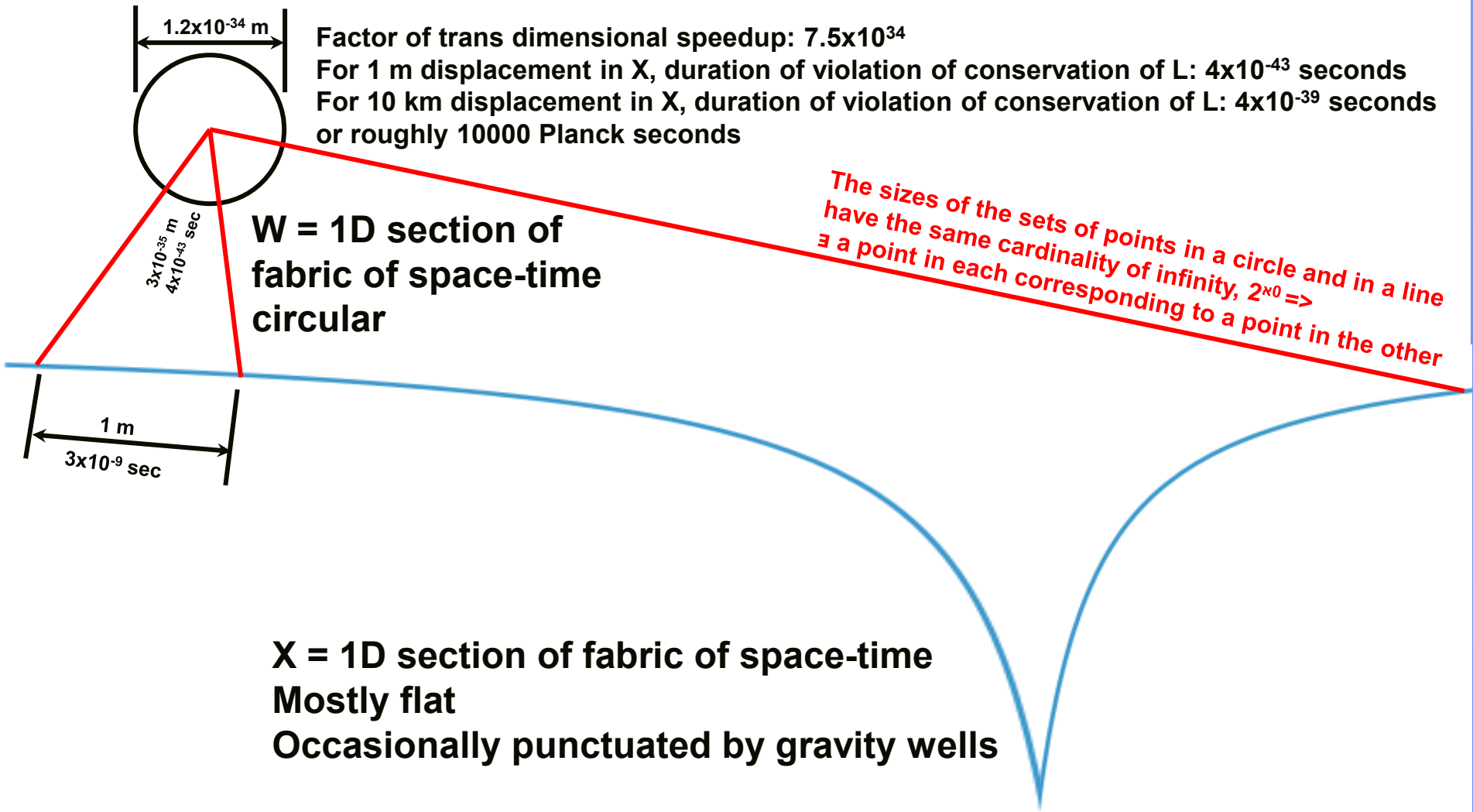
A change in either particle *requires* the other to change instantaneously

Any claim about entanglement not derivable from unfactorablity (college algebra) must be independently and rigorously proven

Couldn’t force carriers be hidden like the cause is hidden?



c is a universal constant ^ conservation of L = Iω is a universal law => transdimensional action fails



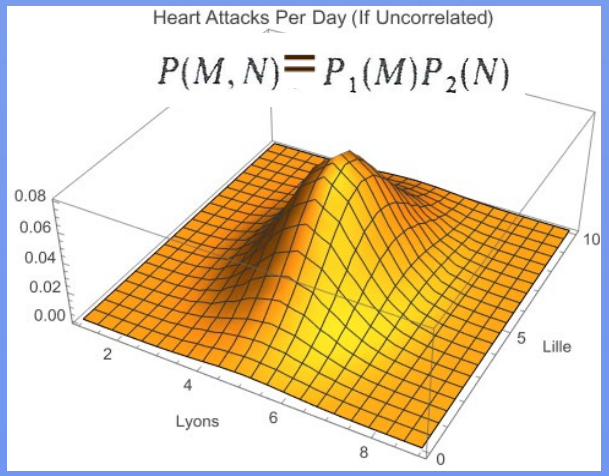
Factor of trans dimensional speedup: 7.5×10^{34}
For 1 m displacement in X, duration of violation of conservation of L: 4×10^{-43} seconds
For 10 km displacement in X, duration of violation of conservation of L: 4×10^{-39} seconds
or roughly 10000 Planck seconds

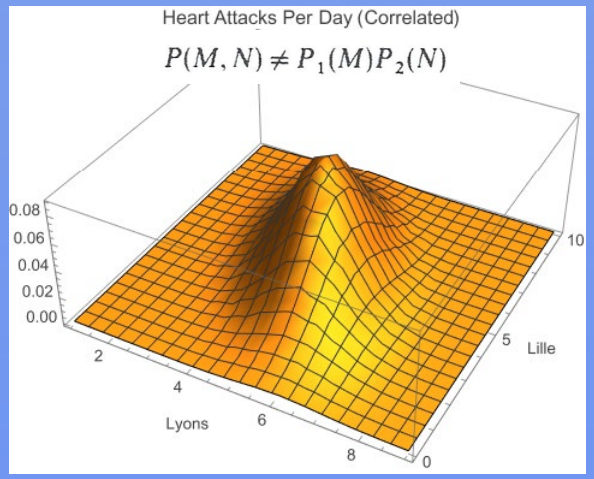
W = 1D section of fabric of space-time circular

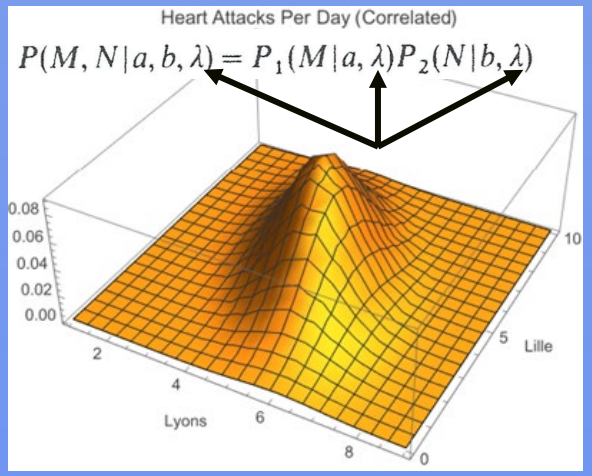
The sizes of the sets of points in a circle and in a line have the same cardinality of infinity, $2^{\aleph 0}$ => ∃ a point in each corresponding to a point in the other

X = 1D section of fabric of space-time
Mostly flat
Occasionally punctuated by gravity wells

How did Bell do it? Hide a variable; what conditions allow it?; EPR fails







$(\psi^*\psi) = p_{\$€}(x,y|\lambda)$

"Integrate out" the unknown λ, a "nuisance parameter:"

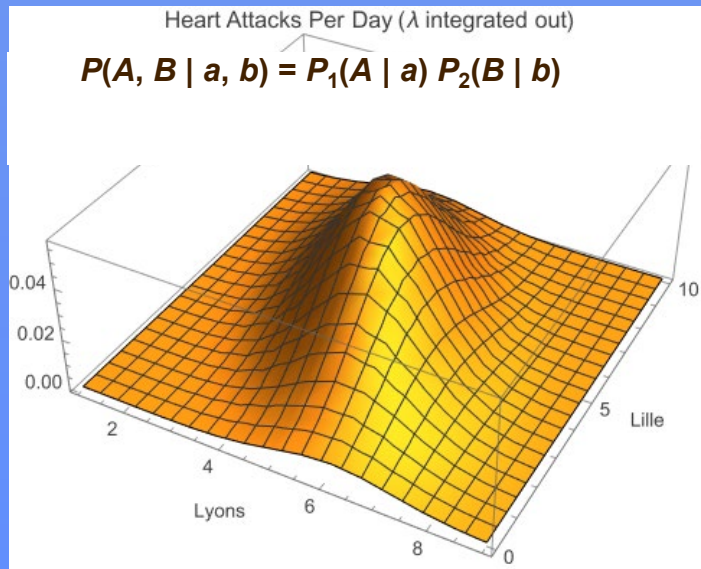
$p_{\$€}(x,y) = \int d\lambda p_{\$€}(x,y|\lambda)f(\lambda)$

$P_{\$€}(x,y|a,b) = \int_{-\infty}^{a} \int_{-\infty}^{b} p_{\$€}(x,y)dxdy$

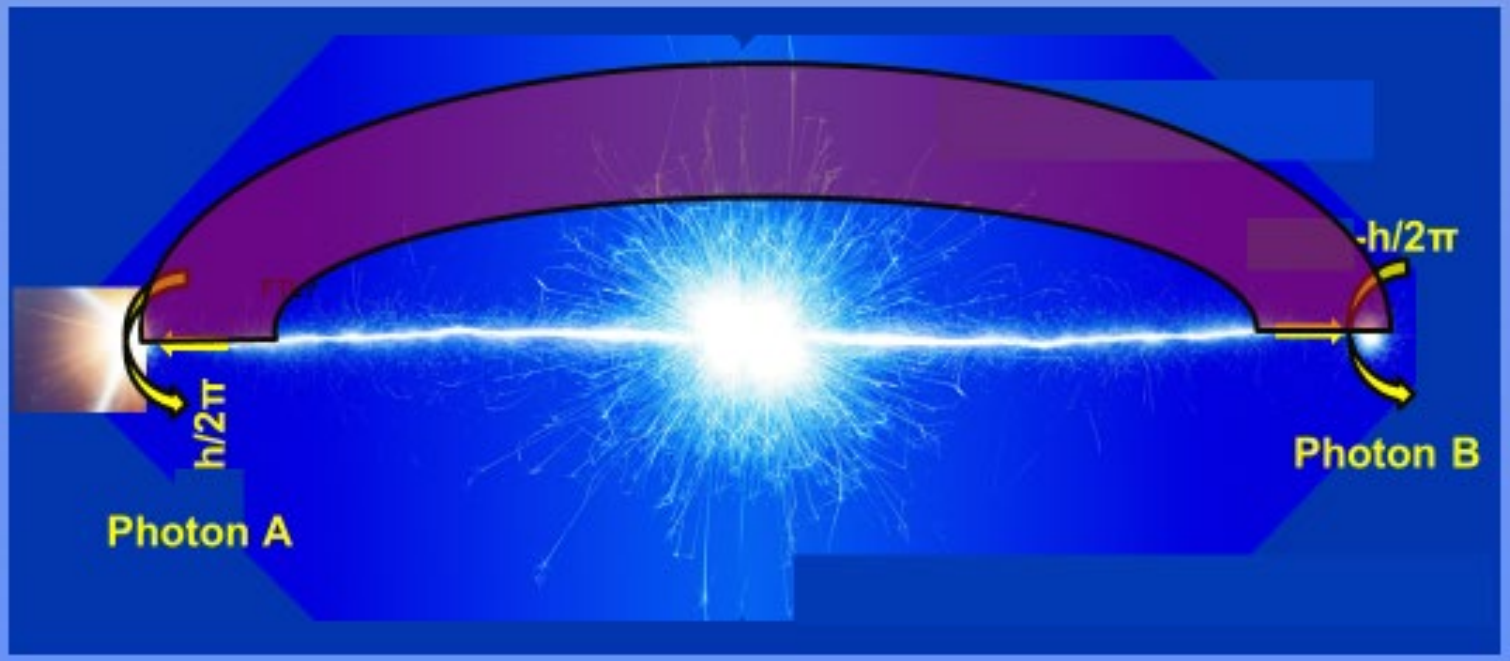
It is the hideability property of the density function that justifies Bell's claim to the hideability of the distribution function

equation (25) in "Bertlmann's socks"

$$P(A,B|a,b) = \int d\lambda\, f(\lambda) P(A,B|a,b,\lambda)$$

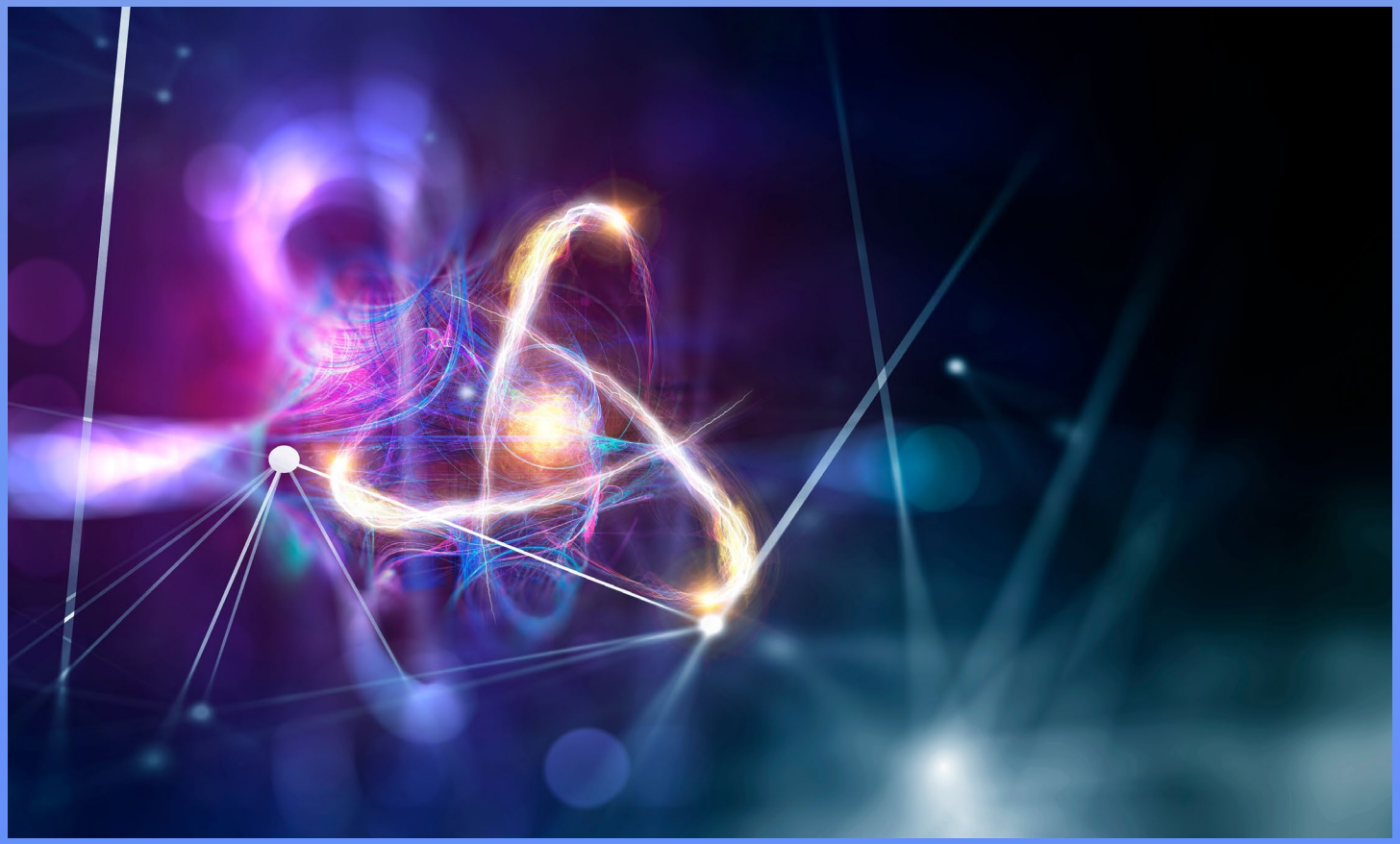


Is there such a thing as emergence of novelty upwardly caused by the interaction of parts?



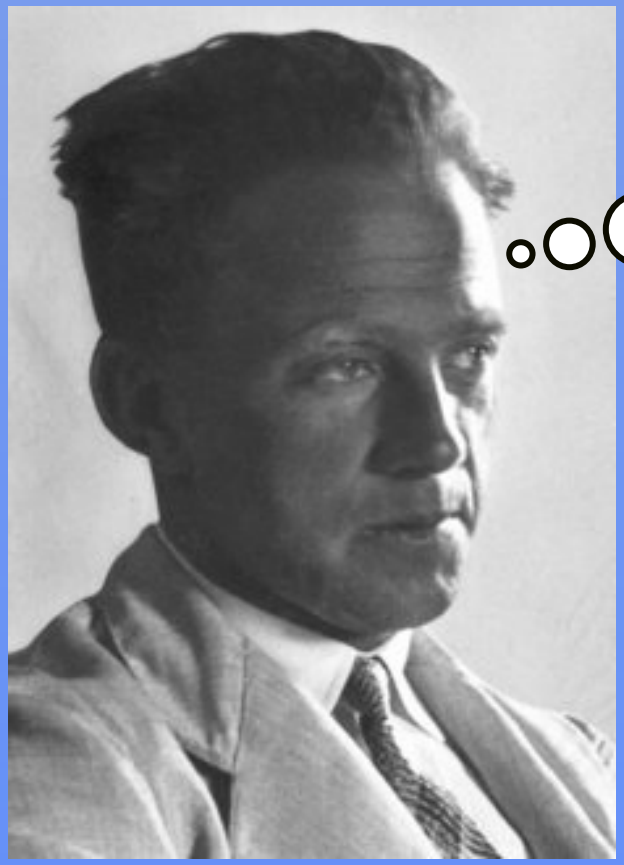
Von Neumann claimed that a big enough collection of interacting parts would exceed a “threshold of complexity” and novelty would “emerge;” Do two “parts” exceed the threshold of complexity?

Carroll argues that there is no "strong emergence," as it would require ambiguous action of the parts



"There's no ambiguity in what the atom is supposed to do, according to our best theory of physics" (Carroll, p. 109)

“Physics has to confine itself to formal description …”



Shut up and calculate

Questions about underlying causation are “useless and meaningless”[13]

Is everything connected to everything else?

Bohm recognized that N-body systems can have both factorable and non-factorable wave functions. He is free to *assume* that the wave function of the entire physical universe, expressed *in configuration space* is non-factorable, hence entangled, and he can ponder the consequences. However, that presumption offers no assurance that the one and only *ontological* wave function of the whole universe is fully non-factorable.

The presumed entanglement of configuration space does not imply that the entire physical universe is entangled. If, at any instant after the big bang, a particle and the pilot wave guiding it are launched simultaneously, the pilot wave never contains more information than what it has accumulated locally as its wavefront propagates through physical space at v = c.

Although the pilot wave can instantaneously tell its particle everything it knows, it never knows everything. Thus, the particle has no connection with particles not yet encountered by the pilot wave. At any moment, the dynamics of the particle are guided by its current incomplete collection of information furnished by the pilot wave.

Bohm is guided by a belief that everything is connected to everything. However, his hypothetical pilot wave does not account for that degree of connectedness. The pilot wave is non-local in its monologue to its particle. However, it is strictly local in its own information gathering process.