Title: Philosophy: Perspectives on the Universe

Speakers: Steven Weinstein

Collection/Series: Lee's Fest: Quantum Gravity and the Nature of Time

Date: June 02, 2025 - 2:30 PM

URL: https://pirsa.org/25060033

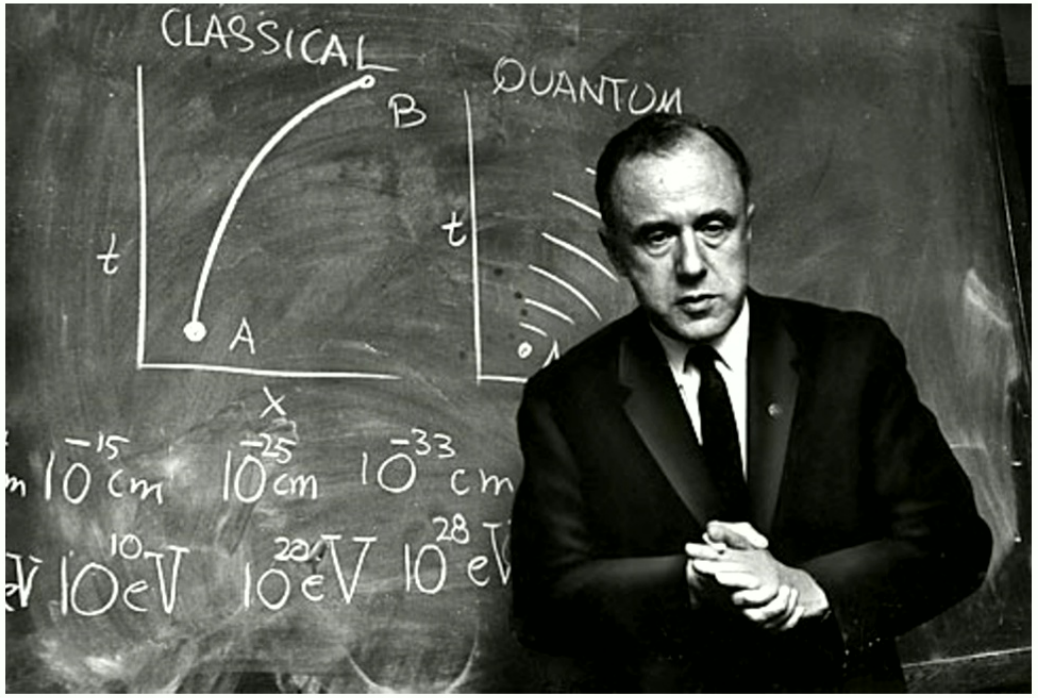
Perspectives on the Universe

Steven Weinstein

University of Waterloo, Perimeter Institute

June 2, 2025

Lunch with John Wheeler: Princeton, May 1998



Princeton University **Department of Physics: Joseph Henry Laboratories**
Jadwin Hall
Post Office Box 708
Princeton, New Jersey 08544-0708

May 20, 1998

Prof. Lee Smolin
PSU Gravity Center
104 Davey Lab.
University Park, PA 16802

Dear Lee:

My wife asked me how the Rutgers conference had gone when I got home that night. I told her that the two most impressive speakers were you and Ed Witten -- that you had used all the profuse gestures of a professional hypnotist and that he had been the image of a Presbyterian preacher, serious face, standing perfectly rigid with his hands at his side and speaking as if reading from the gospel.

Seriously, I thank you for your talk which Steve Weinstein and I have just been discussing at lunch today. The Holographic Hypothesis I would like to translate into the realm of electromagnetism, "Give the electric field over a closed boundary. Then, there is only one configuration possible for the electric field inside of that boundary." But you can see for yourself that this proposition is crazy. This circumstance, which we have been discussing today, raises the question or increases the suspicion that the "Holographic Hypothesis" is cuckoo. Or are we cuckoo? Save us!

Best wishes from us both. And if you write, please send duplicate copies to us at these two addresses. Thanks again.

Sincerely,

Prof. John A. Wheeler
Dept. of Physics
Princeton University
Princeton, NJ 08544-0708

Dr. Steve Weinstein
Dept. of Philosophy
Northwestern University
818 Hinman Ave.
Evanston, IL 60208-1315

Telephone: 609-258-4400 FAX: 609-258-1124

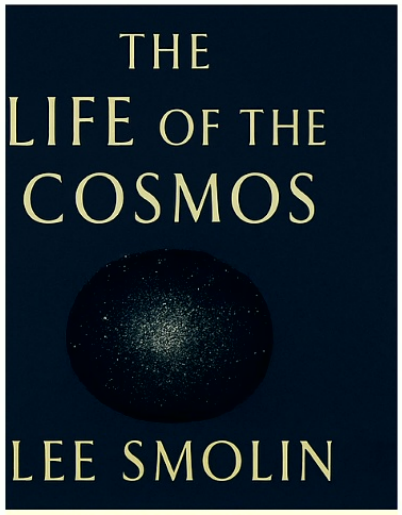
Introduction

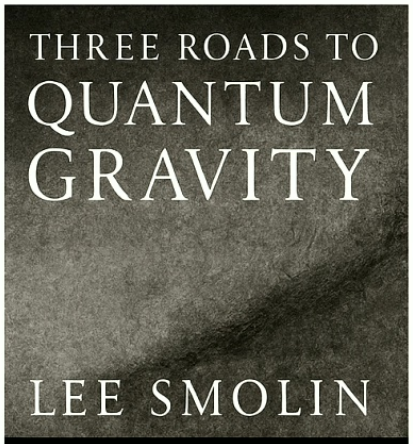
Lee's earliest work was on the quantization of general relativity, a theory that describes gravity as an effect resulting from the curvature of spacetime by matter. Thus there is a vital connection between theories of the universe – of cosmology – and the theory of gravity, because gravity explains the shape of space and time. And *quantum* gravity presents significant new challenges of its own.

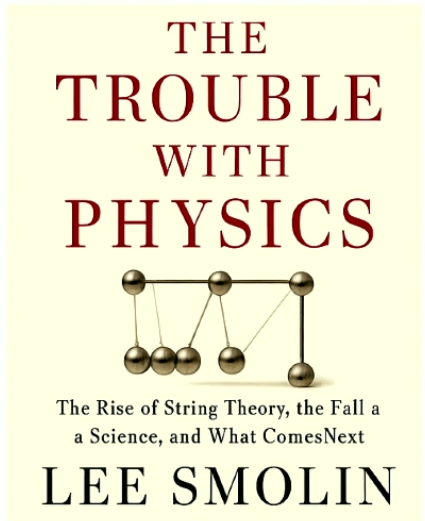
Indeed, any theory in which time plays a special role – really, any physical theory – is impacted by one's theory of gravity. The philosophical puzzles that arise when one is theorizing about space and time have been part and parcel of Lee's work on cosmology and on the interpretation of quantum mechanics. He has also taken considerable time to debate the adequacy of superstring theory to address these questions.

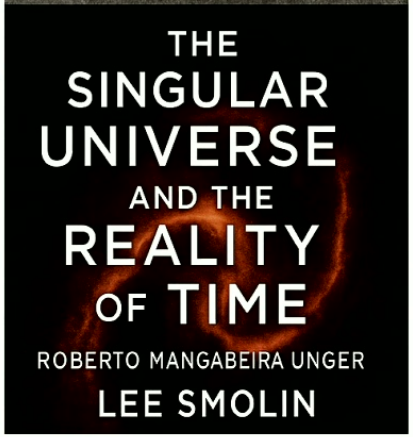
- Holography
- Relationalism about Space and Time (Leibniz, Galileo, and Einstein)
- Multiverse Cosmology (Natural Selection) & Origin of the Laws of Nature: Universe vs. Multiverse
- Quantum Mechanics and Its Limits

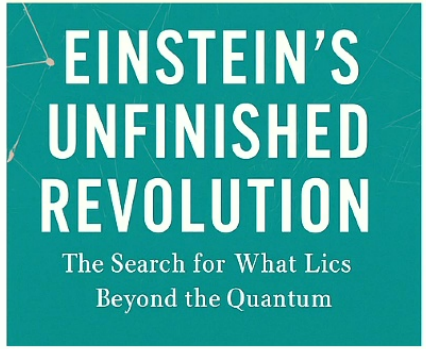
Popular Works





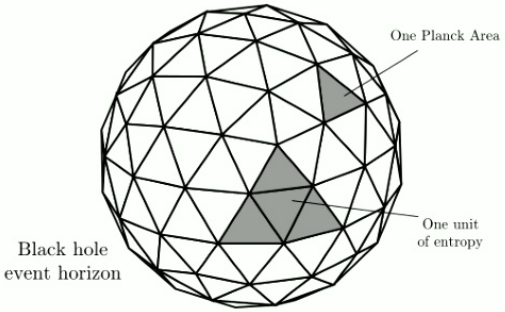






Holography

- Lee's ideas about holography were advanced in the late 1990s and discussed in his popular book *The Life of the Cosmos*, inspired in part by earlier work of 't Hooft, Susskind, and Crane in the early 1990s.
- All of this work owes a huge debt to John Wheeler's student Jakob Bekenstein, who had famously showed in 1981 that the maximum amount of information that could be packed into a volume of space was proportional not to the *volume* but to the area of the surface enclosing the volume.



- Thus it seems that if one knew the right sort of description, one could for example read off what is going on inside the human body by carefully describing the surface of the body.

Holography

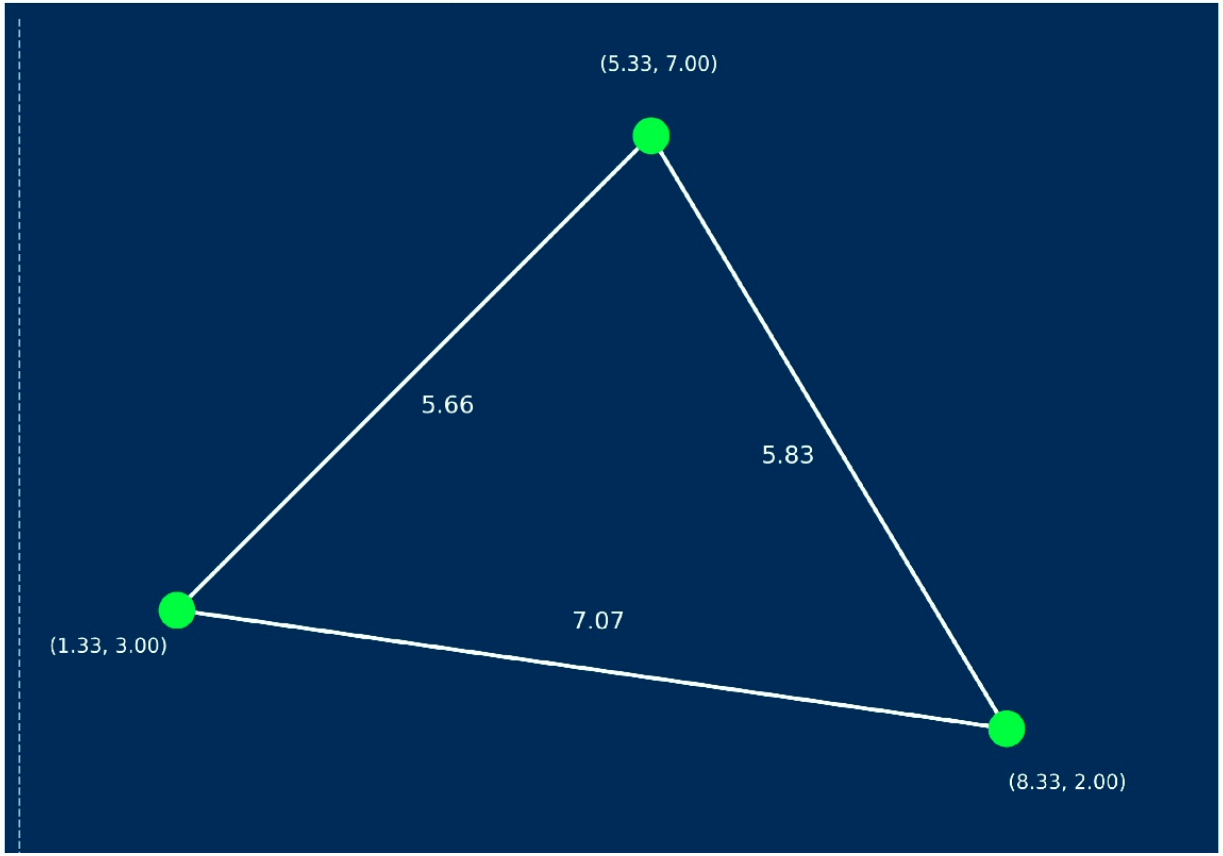
- Lee hypothesized that objects interact with other objects not directly, but via the interaction of what he called Screens, the surfaces surrounding the objects. The object -plus-screen he called a "nad", alluding to Leibniz's related idea of a world of "monads".
- The idea that we don't see things-in-themselves is straight out of Kant. Kant called them "noumena", whose thinking was heavily influenced by Leibniz. So Lee's ideas here are part of a great philosophical tradition.
- Though the holographic aspects were largely put to the side in later work, the core philosophical idea — that what is physically essential is relations between objects, rather than the objects themselves — continues to this day to play an enormous role in his thinking.

Relativity, Relationalism & Background Independence

- Classical general relativity is formulated in such a way that physical content is independent of the background manifold over which the gravitational field is specified. The gravitational field itself is what gives the points of the manifold their physical significance.
- The requirement that the theory be background-independent is the origin of Lee's *relationalism* about space and time. This is an idea that originates in Galileo's theory of relativity, which was effectively incorporated by Newton, and later built into both special and general relativity. But whereas Newton thought that space and time had an independent existence – he felt they were "God's sensorium," Leibniz urged a thoroughgoing relationalism whereby only relative positions and velocities of objects were to be regarded as real.
- *No objects, no space. No clocks, no time.*

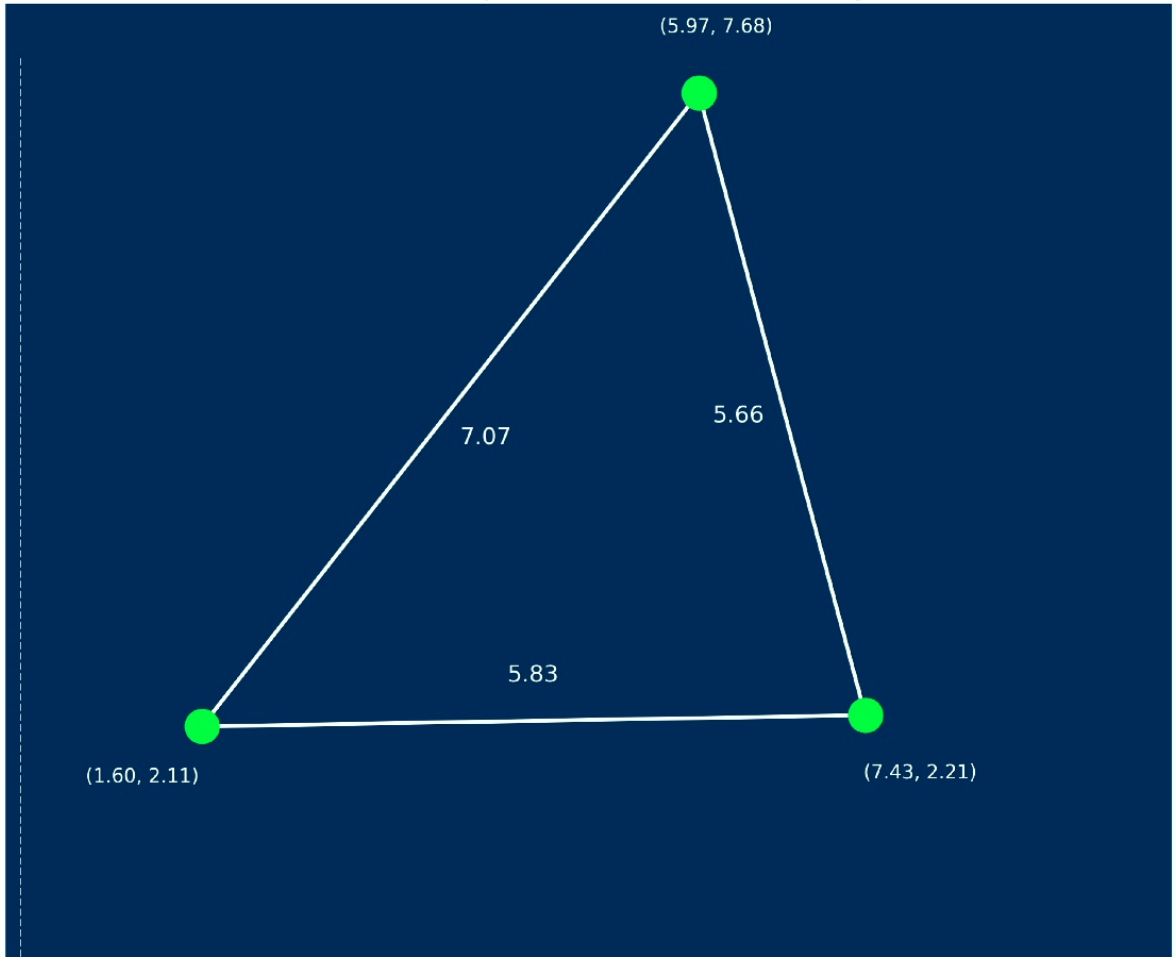
Relationalism

Relationalism: "Space is nothing apart from the things that exist; it is only an aspect of the relationships that hold between things." (Three Roads to Quantum Gravity)



Relationalism & Holography

Same three objects, rotated 120 degrees.



The Problem of Time

- In canonical quantum gravity, there are four constraint equations, three of which encode the relational feature we just discussed. They generate small shifts in each of the three spatial directions. They are structured so that the relations between objects remain the same.
- The fourth constraint is the Wheeler-DeWitt equation, which has to do with moving from one "moment of time" to the next. Classically, this can be tricky, but whatever philosophical issues arise are manageable.
- When quantizing, however, the last constraint gives rise to the notorious "problem of time," and it has led many great physicists to proclaim that time itself is not real, that time-evolution is a difference without a difference, much like the way in which spatial rearrangement at a given time is a difference without a difference.
- Because time plays such a fundamental role in our theories, this can create great difficulty. The quest to understand and deal with this problem is a large part of Lee's life's work, and I believe is a principle driver of the change in his view about the nature of time that comes in the early 2010s, in his work with Roberto Unger.

Cosmology

- The other impetus behind Lee's thinking is a desire to formulate a theory that applies to the entire universe. The difficulties are two-fold: (1) quantum mechanics is much better adapted to describing subsystems, with which an external observer interacts, (2) many contemporary cosmological theories invoke a multitude of unobservable worlds known colloquially as the multiverse. How can we confirm such theories, or falsify them? Are we still doing science?
- Furthermore, Lee and his collaborators are attempting to explain *where* the laws of nature come from. Lee's early work on cosmological natural selection and his more recent work on evolving laws with Roberto Unger enter the picture.

Cosmology as Science: The Big Bang model

- From our vantage point on Earth, the universe appears to be quite uniform on large scales, and appears to have been expanding for around 13.8 billion years, with the earliest times being described by a hot big-bang. This is modelled by the Robertson-Walker solutions of Einstein's general relativity.
- Applying the so-called Cosmological or Copernican Principle – the principle that we don't occupy a special place – cosmologists from the 1940s-1970s generally inferred that the universe as a whole is spatially infinite and expanding, just like the part we can observe.

Cosmology as Science: Inflation & The Multiverse

- In the early 1980s, several theorists proposed variants on the big bang model that were intended to explain why the universe was so uniform in the first place. These all involved a new, heretofore unobserved field called the inflaton. The inflaton has peculiar gravitational properties, which under the right circumstances take what might be a rather inhomogeneous initial distribution of matter and expand it quite quickly so that the inhomogeneities were washed out. This leaves a uniform state that looks like the initial state of the big bang model.
- Further development suggested that an inflationary universe, if it were infinite, would keep inflating in most places, and that universes such as ours were the very occasional result of what came to be called bubble nucleation. Hence the term *multiverse*.

The Multiverse

- There are at least two philosophical or methodological difficulties with this eternal inflation scenario:

1. Unless there is a "bubble collision", the infinity of other universes that come along with eternal inflation are unobservable. How can we test such a theory?
2. As Roger Penrose and others have pointed out, inflation itself requires special initial conditions to get started. Insofar as it was hypothesized as a way of explaining the apparent specialness of the initial conditions, how does it even help?

- Finally, and most ambitiously, shouldn't a proper cosmological theory explain why the universe obeys the particular laws that it does? If so, could such an explanation be testable? Lee and collaborators have devoted a great deal of thought to what sort of hypotheses might explain why our laws have the form they do.

Cosmology as Science: Natural Selection

- Lee's idea of Cosmological Natural Selection (1992, 1997) presented an alternative to eternal inflation which accomplished three things: (1) no special initial conditions, (2) falsifiable, and (3) explained why the laws of nature are as they appear.
- The central idea is that when a star or galaxy undergoes gravitational collapse and forms a black hole, the matter inside is reprocessed and gives rise to a new universe, with laws that may vary slightly from the laws associated with the parent universe. Some of these universes are more conducive to the formation of black holes than others. So the laws of nature are evolving, and the laws that give rise to more black holes are favored, because they have more progeny.
- The idea of evolving laws of nature goes back at least to the philosopher C.S. Pierce, and the idea that black hole singularities reprocess information was proposed by John Wheeler.

Time Reborn: Temporal Naturalism

- Cosmological Natural Selection gives a framework in which to think about the laws of nature evolving. But it introduces a multiverse, and is not entirely specific about the mechanism by which new universes are created.
- Since around 2013, however, Lee and philosopher Roberto Unger have advocated for a simultaneously radical and conservative rethinking of the nature of time called *temporal naturalism*. In this new view, time is held to be "real". What this means is both that there is a preferred *foliation* of spacetime, and that there is a preferred *direction* of time.

Time Reborn: Temporal Naturalism

- With a preferred direction, one can claim that the past was real, the present is real, but the future is truly open.
- Time is still relational in one sense, in that observations of its passage are observations of the motion of clocks. But there are a preferred set of clocks which reflect the passage of the true, real time.
- At the classical level, it relies on the *shape dynamics* approach to general relativity, which works with a preferred set of instants. At the microscopic level, Lee and Marina Cortes have worked on *energetic causal sets* that incorporate a fundamental arrow of time.

Evolving Laws

- A notable difference between this new idea of evolving laws versus the one used in CNS is that in this new view, there is only a *single universe*.
- Following earlier work of Lee with Julian Barbour, Lee & Roberto Unger conjecture that the universe may evolve in such a way as to exhibit *maximal variety*, an analogue of Leibniz's conjecture that this is the best of all possible worlds.
- Smolin and Unger realize, though, that this is a meta-law of sorts. The framework urges that no laws are eternal, that all things are subject to change, and so the way in which the laws of nature evolve is still open, as indeed it must be.

Quantum Mechanics

- Lee's recent work with Clelia Verde on *The quantum mechanics of the present* (2021) goes into more depth on this radical new way of conceiving the role of quantum mechanics in describing the physical world.
- "We propose a reformulation of quantum mechanics in which the distinction between definite and indefinite becomes the fundamental primitive. Inspired by suggestions of Heisenberg, Schrodinger and Dyson that the past can't be described in terms of wavefunctions and operators, so that the uncertainty principle does not apply to past events, we propose that the distinction between past, present and future is derivative of the fundamental distinction between indefinite and definite."
- "Neither the past nor the future fully exist, but for different reasons. We finally suggest reformulating physics in terms of a new class of time coordinates in which the present time of a future event measures a countdown to the present moment in which that event will happen."

The Future of Time

- From a philosophical standpoint, Lee has consistently advocated a kind of Leibnizian relationalism about space. Like Leibniz, he does not believe in the reality of space.
- And like Leibniz, Lee believes that our observational access to time is strictly relational – time is what clocks measure. But unlike Leibniz, Lee now believes that not all clocks are created equal. Some of them reflect the *true* time, a time which plays a role in fundamental physics unimagined by the likes of Leibniz.
- The preferred time gives us a possible way to address the problem of time in quantum gravity, and makes room for a realist approach to thinking about the physics that underlies the otherwise paradoxical theory of quantum mechanics.
- The commitment to a fundamental direction of time presents obvious challenges to the derivation of what are currently thought of as fundamental laws, such as the time-reversal invariant laws of particle-physics, but presents an opportunity in that it may help to explain how the laws of nature and the things in it have come to have the properties they have, and how they might evolve in the future.

"Salad Days"

Lee, Rafael Sorkin, SW, Gerard 't Hooft (2008)