Title: Time Reborn

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Abstract: What is time? Is our perception of time passing an illusion which hides a deeper, timeless reality? Or is it real, indeed, the most real aspect of our experience of the world? Einstein said that "the distinction between past, present, and future is only a stubbornly persistent illusion," and many contemporary theorists agree that time emerges from a more fundamental timeless quantum universe. But, in recent cosmological speculation, this timeless picture of nature seems to have reached a dead end, populated by infinite numbers of imagined unobservable universes.

In his talk, Lee Smolin explains why he changed his mind about the nature of time. Like many fellow theorists, he used to believe time is an illusion, but he now embraces the view that time is real and everything else, including the laws of nature, evolves. Drawing from his new book, Time Reborn, Smolin explains how the great unsolved problems in physics and cosmology may be solved by adopting the view of a real time. then he will go beyond physics to explain how our view of time affects how we think of everything from our personal and family lives to how we face major problems such as climate change and economic crisis. In a world in which time is real, the future is open and there is an essential role for human agency and imagination in envisioning and shaping a good future.


Time Reborn
Lee Smolin
PI
April 3 2013
www.timereborn.com
TIME
REBORN
Lee Smolin

Science began with time:

All things originate from one another,
and vanish into one another
according to necessity...
in conformity with the order of time.

-Anaximander, On Nature.

1 Questions
2 The old paradigm: physics of parts of the universe
3 Time and cosmological Physics
4 Implications

In 2080 the averaged temperature on Earth will be 6 degrees warmer than now.

Can we choose to influence it?

Is time real?

Is truth timeless?

Or is all truth,
true in a moment?

Does time emerge from timeless law?

Or does law emerge and evolve in time?

Is the future already determined?

Or is it open?

Is novelty possible?

If we knew everything
about an instant,
could we be surprised
by the next?

Do our laws apply only to small parts of a big universe?

Are there different kinds of laws that apply to the universe as a whole?

Do we have more or less freedom as we grow older?

Some old answers from physics:

Fundamentally, nothing happens except rearrangement of atoms according to timeless laws. *Novelty is an illusion.*

The laws of physics are deterministic, so the future is already completely determined.

Free will is impossible.

Thomasina:

If you could stop every atom in its position and direction,
and if your mind could comprehend all the actions thus suspended,
then if you were really, really good at algebra
you could write the formula for all the future;
and although nobody can be so clever as to do it,
the formula must exist just as if one could.

ARCADIA: Tom Stoppard

Sabine Hossenfelder wonders:


So he must believe
he is a mathematical
structure as well...


. . . and I am a
mathematical structure
too


I wonder what it feels like, being a mathematical structure.

To set up a theory in the Newtonian paradigm answer two questions:

- What are the possible states or configurations of the system at a fixed time?

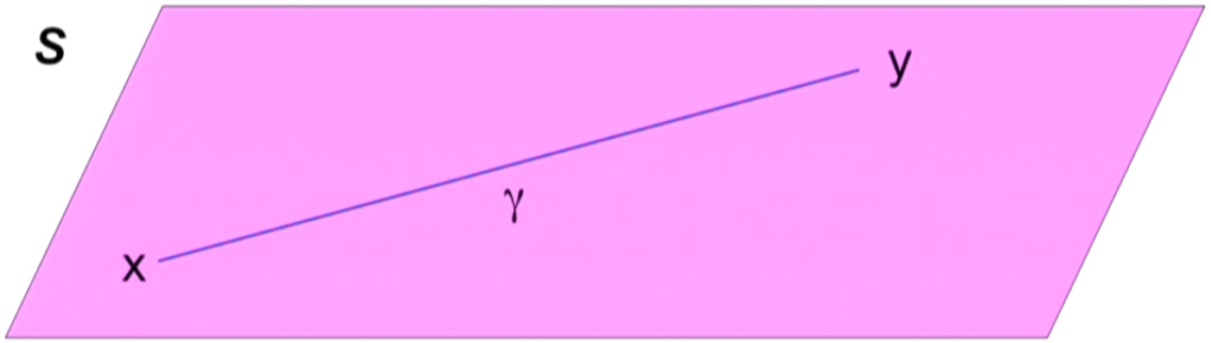
- How do these states change in time?

The Newtonian schema:

- A state space, **S**, is constructed, It is assumed invariant under time. In classical mechanics this is the phase space of configuration, momentum pairs. In quantum mechanics it is the Hilbert space.

The Newtonian schema:

- To apply this schema to an experiment one prepares the system at an initial time, $\mathbf{t_1}$, in a state **x** of **S**. One then waits till a time $\mathbf{t_2}$ and observes what state, **y** of **S** the system is in. The clock by which time is measured is assumed to be external to the isolated system.



Time is eliminated in applications of the Newtonian schema:

- It is geometricized ie represented as if it were a dimension of space.
- Causal implications, played out in time, are represented by timeless logical implication.
- Observables at any time are reduced by use of the equations of motion to functions of the initial conditions.
- In thermodynamics time averaging is shown to be equivalent to ensemble averaging.

Hence, from the Newtonian paradigm there are arguments that time is inessential for the most fundamental description of nature.

All successful applications of the Newtonian schema so far are either to subsystems of the universe or are gross approximations.

Those are always approximate because interactions between the subsystem and environment are neglected.

THESIS:

A truly fundamental theory must be a cosmological theory.

Any theory short of a cosmological theory is a truncation that neglects interactions between subsystems and the environment and is therefore approximate.

The cosmological dilemma:

-All applications of the Newtonian paradigm to subsystems of the universe are approximate-because interactions with the outside are neglected.

-But when you expand the subsystem to the universe as a whole you loose explanatory power, for the reasons just indicated.

By the reality of time we will mean:

-All that is real is real in a present moment, which is one of a succession of moments.

-There are no timeless laws acting to cause evolution in time.

-There is an objective distinction between the past, present and future.

-There is no mathematical object which is the timeless mirror of the history of the universe.

The future and the past:

- The past was real but is no longer real. We can, however, interpret and analyze the past, because we find evidence of past processes in the present.

- The future does not yet exist and is therefore open. We can reasonably infer some predictions, but we cannot predict the future completely. Indeed, the future can produce phenomena that are genuinely novel, in the sense that no knowledge of the past could have anticipated them.

- Nothing transcends time, not even the laws of nature. Laws are not timeless. Like everything else, they are features of the present, and they can evolve over time.

Einstein's ambivalence:

"People like us,
who believe in physics,
know that the distinction
between past, present, and future
is only a stubbornly persistent illusion."

Once Einstein said that the problem of the Now worried him seriously. He explained that the experience of the Now means something special for man, something essentially different from the past and the future, but that this important difference does not and cannot occur within physics. That this experience cannot be grasped by science seemed to him a matter of painful but inevitable resignation. I remarked that all that occurs objectively can be described in science; on the one hand the temporal sequence of events is described in physics; and, on the other hand, the peculiarities of man's experiences with respect to time, including his different attitude towards past, present, and future, can be described and (in principle) explained in psychology.

Carnap, 1963

But Einstein thought that these scientific descriptions cannot possibly satisfy our human needs; that there is something essential about the Now which is just outside the realm of science.

We both agreed that this was not a question of a defect for which science could be blamed, as Bergson thought. I did not wish to press the point, because I wanted primarily to understand his personal attitude to the problem rather than to clarify the theoretical situation. But I definitely had the impression that Einstein's thinking on this point involved a lack of distinction between experience and knowledge. Since science in principle can say all that can be said, there is no unanswerable question left. But though there is no theoretical question left, there is still the common human emotional experience, which is sometimes disturbing for special psychological reasons.

Carnap, 1963

We begin the search for a new paradigm for cosmology by proposing new hypotheses and principles

Two theses:

Monoworldism: There is only one universe and it is the one that we observe ourselves to be within. Everything that exists or happens is causally connected to what we see.

The reality of time: Everything that exists or is real, exists at a moment, which is one of a succession of moments. In each moment all that is real is what exists at that moment.

These forbid the transcendental ambition to discover a timeless mathematical object (the solution to a timeless law of nature) which mirrors every property of the history of the universe. There is no copy of the universe from outside of it, no "real timeless reality" to transcend to, the universe is not essentially mathematical. The timebound world is all there is.

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One property that the real world has that is shared by no mathematical object suffices to prove the point: ***in the real world it is always some moment.***

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If time is real we can use it to try to explain the why these laws question:

- The present laws must have evolved in time, so that they can be explained by the mechanism of evolution.

- This requires that the initial singularity be a bounce from a previous area, ie a deep history of the universe going back through a succession of eons.

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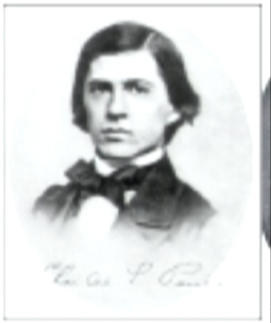

"To suppose universal laws of nature capable of being apprehended by the mind and yet having no reason for their special forms, but standing inexplicable and irrational, is hardly a justifiable position. Uniformities are precisely the sort of facts that need to be accounted for. Law is par excellence the thing that wants a reason. ***Now the only possible way of accounting for the laws of nature, and for uniformity in general, is to suppose them results of evolution.***"

Charles Sanders Peirce (1893):

Roberto Mangabeira Unger

You can trace properties of the present universe back to the properties it must have had at the beginning. But you cannot show that these are the only properties that the universe might have had…Earlier or later universe might have had entirely different laws…To state the laws of nature is not to describe or explain all possible histories of all possible universes. Only a relative distinction exists between law like explanation and narration of a one time historical sequence.

If you are asked what you mean by the necessity of the laws of nature (that is to say by the necessity of the most necessary relations), you can legitimately respond only by laying out the substance of your cosmological and other scientific ideas. People who appeal to fixed conceptions of necessity, contingency and possibility are simply confused.

At the beginning of time the laws of Nature were probably very different from what they are now. Thus, we should consider the laws of Nature as continually changing with the epoch, instead of as holding uniformly throughout space-time.

-Paul Dirac

The only field which has not admitted any evolutionary question is physics. Here are the laws, we say,...but how did they get that way, in time?...So, it might turn out that they are not the same [laws] all the time and that there is a historical, evolutionary, question.

-Richard Feynman

http://www.youtube.com/watch?v=uNOghidK2TY

Reprocessing the universe...

-John Archibald Wheeler

There are specific hypotheses for the evolution of laws of physics on a cosmological scale:

-cosmological natural selection

-the principle of precedence in quantum theory

The Principle of Precedence: arXiv:1205.3707

If we prepare and measure a quantum system we have studied many times in the past, the response will be as if the outcome were randomly chosen from the ensemble of past instances of that preparation and measurement.

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But this is a wild idea!!

What kind of thing is a law that lives outside of time but can act in time on every material process?

How does an electron know it is supposed to follow the electron law rather than the quark law?

There is a radical metaphysical idea at work, making the crazy seem obvious.

The Principle of Precedence:

There is a less radical assumption: What was just stated is the only law of nature needed.

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If we prepare and measure a quantum system we have studied many times in the past, the response will be randomly chosen from the ensemble of past instances of that preparation and measurement.

That ensemble is real, hence nothing unreal or uninfluenceable is reaching into the universe to act on the real.

To explain this we need a fundamental theory in which the present and past are meaningful.

Testable because novel quantum systems shouldn't obey quantum mechanics.

Cosmological natural selection:

• Universes reproduce by black hole singularities "bouncing", giving rise to new regions of spacetime.
•At each bounce the parameters of the laws of physics mutate slightly.

Consequently:

•A typical universe is most likely to come from a parent that had many progeny than few.

•If our universe is typical then it is likely to be tuned to maximize the production of black holes.

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Cosmological natural selection:

If our universe is typical then it is likely to be tuned to maximize the production of black holes.

This explains many features of our laws:

- Star formation requires plentiful carbon and oxygen.
- Supernovas require tuning of weak interactions.
- Gravity must be very weak.

This makes several falsifiable predictions

- The heaviest stable neutron star must be less than twice the sun's mass.
- Inflation, if true, must be single field, single parameter.

Both have so far survived non-trivial experimental tests.

The reality of time also allows a straightforward explanation of a manifest but otherwise inexplicable property of our universe, which is that the universe is asymmetric in time.

To conclude:

The hypothesis of the reality of time offers opportunities to search for new explanations for unsolved foundational questions:

- To explain the selection of laws due to evolution in time.
- New approaches to the foundations of quantum physics.
- New approaches to explaining the arrows of time.

If laws evolve, time must be real. Time does not emerge from law, time is what remains when the limits of law are surpassed.

The future may be genuinely open and not predictable.

Nature may have a genuine element of freedom from determination by the past.

Surprise and novelty are real, not illusion.

This leads to a more scientific, more testable cosmological theory than the attempt to apply timeless law to the universe as a whole.

What does this mean for us?

The future is open and yet to be made.

We can choose to influence it.

Imagination is essential.

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