

Title: Causal Set Quantum Gravity and the Hard Problem of Consciousness

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Series: Quantum Gravity

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Abstract: In this talk I will develop Rafael D. Sorkin's heuristic that a partially ordered process of the birth of spacetime atoms in causal set quantum gravity can provide an objective physical correlate of our perception of time passing. I will argue that one cannot have an external, fully objective picture of the birth process because the order in which the spacetime atoms are born is a partial order. I propose that live experience in causal set theory is an internal "view" of the objective birth process in which events that are neural correlates of consciousness occur. In causal set theory, what "breathes fire" into a neural correlate of consciousness is that which breathes fire into the whole universe: the unceasing, partially ordered process of the birth of spacetime atoms.

Zoom link: <https://ptp.zoom.us/j/95170823205?pwd=QW9YM3QrZU12Ti9HTUQ4TDlVNmN5Zz09>

Einstein's diagram of his epistemology of science

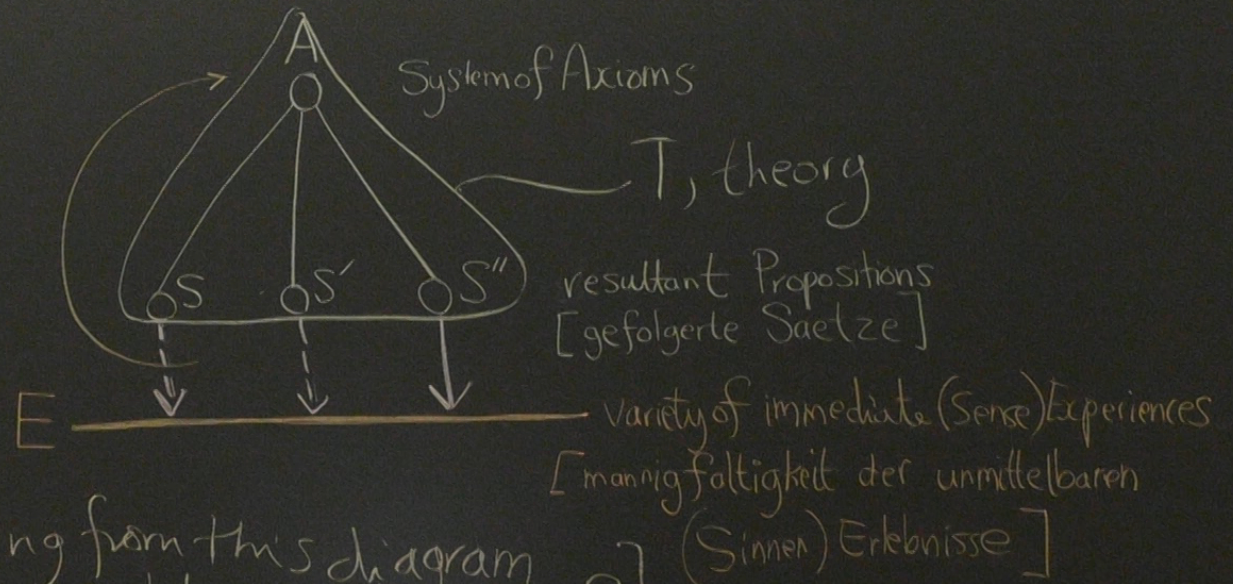
Quotations from Einstein's Autobiographical Notes (AN) and his 1952 letter to Maurice Solovine (LS)

- ▶ AN: I see on the one side the totality of sense-experiences, on the other side the totality of the concepts and propositions that are laid down in books.
- ▶ LS: The E's (immediate experiences) are given to us. [I don't think Einstein means to deny that E is shaped by T. Consider experience of seeing a STOP sign]
- ▶ AN: The concepts and propositions acquire "meaning" and "content", respectively, only through their relation to sense-experiences. The connection of the latter with the former is purely intuitive, not itself of a logical nature. The degree of certainty with which this relation or intuitive connection can be made, and nothing else, is what differentiates empty fantasy from scientific "truth".
- ▶ LS: What this all boils down to is the eternally problematical connection between the world of ideas and that which can be experienced (immediate experiences of the senses).

This talk will discuss the connection between the world of ideas and that which is experienced.

So it is going to be intuitive, nonlogical, and problematic.

A. Einstein in letter to M. Solovine 7 May 1952



[Q: What is missing from this diagram that one might expect to see?] (Sinnen) Erlebnisse]

The Hard Problem of consciousness

Suppose there is a theory of “Neural Correlates of Consciousness” (NCC) that says such-and-such an event in A 's brain, E_{neur} say, correlates with subject A having so-and-so conscious experience. Consider then “the argument from knowledge” (Jackson 1982):

- ▶ If A grows up locked in a black and white room and learns everything there is to know about the NCC theory, then when she steps outside the room and experiences colours for the first time she gains new knowledge about the world. The knowledge of *what it is like* to experience colours.
- ▶ Ergo there's *something missing* from any NCC theory.

Finding what is missing is what is called “solving the Hard Problem”. It is “hard” because, according to the above argument, anything one adds to the NCC theory of the same ilk as “such-and-such event in the brain”, no matter what it is, does not teach A *what it is like* to experience colours.

The Hard problem also looks hard by the light of Einstein's epistemology. One has to create concepts of sense-experiences and lay these down in books (e.g. the term “qualia” is one attempt to do this). Then one must make connections between the experience-concepts in T and actual experiences in E with some “degree of certainty” (or else T is just empty fantasy).

Eddington in Gifford Lectures Chapter V: Becoming

- ▶ “Unless we have been altogether misreading the significance of the world outside us—by interpreting it in terms of evolution and progress, instead of a static extension—we must regard the feeling of “becoming” as (in some respects at least) a true mental insight into the physical condition which determines it.
- ▶ “But if there is any experience in which this mystery of mental recognition can be interpreted as insight rather than image-building, it should be the experience of “becoming”
- ▶ “The view here advocated is tantamount to an admission that consciousness, looking out through a private door, can learn by direct insight an underlying character of the world which physical measurements do not betray.”

Idea: the experience of “becoming”, the perception of the passage of time is the aspect of conscious experience to which the Hard Problem pertains. Then, to solve the Hard Problem we need to find a physical correlate of this perception.

Sorkin's Heuristic

In "Relativity theory does not imply that the future already exists: A Counterexample" Rafael Sorkin states:

It [the example of sequential growth models for causal sets] even provides an objective correlate of our subjective perception of "time passing" in the unceasing cascade of birth-events that build up the causal set, by "accretion" as it were.

I reframe it slightly into the following form:

The Heuristic: the **process** of the partially ordered birth of the atomic-events that compose E_{neur} in causal set theory correlates with the **A having** the corresponding conscious experience in real time.

In other words, what is "missing" from the NCC theory is the birth *process*. I could just end the talk here and let you muse on this idea! But let me expand on it a little, remind you about causal sets and then list a bunch of *connections* between properties of the process and reported qualities of conscious experience. Throughout, I will assume a classical view in which spacetime is a single causal set.

The connections are woven from two threads: (I) process and (II) partial order.

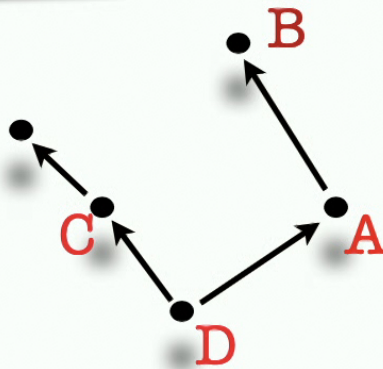
Process and the concept of **events** e.g. the random walk

- ▶ Two ways to conceive of a random walk on the integers: (a) a *dynamic* process and (b) a *static* measure theory
- ▶ (a) The walker steps to the left or right at each stage, with certain transition probabilities.
- ▶ (b) Consider all possible completed histories of the walker (infinite sequences of integers) in a big bag Ω . An **event** is a measurable subset of Ω . e.g. "walker is at 5 at stage 13" = $\{\gamma(t) \in \Omega \mid \gamma(13) = 5\}$.
- ▶ (b) Stochastic "process" in name only: choose one completed "Block Universe" history at random from the bag. That history is the world and each event either has occurred or has not occurred in the world.
- ▶ Mathematics favours (b). Theorems!
- ▶ **(a) and (b) are different physically.** In (a) there is the process of stepping and a physical order in which the steps occur.
- ▶ In (a) there is a **difference** between an event and its occurrence. When I want to emphasise this I call an event, an event-as-such.
- ▶ In (b) there is no stepping, there is no occurring.
- ▶ There is an **external** picture of both—(a) dynamic (movie) (b) static (on paper)
- ▶ This concept of event in physics as "something that might happen \equiv set of histories" exists also in "deterministic" theories such as GR. Uncertainty about initial/external conditions means that there is also contingency for events in such theories.

Causal Set approach to quantum gravity (3 pillars)

1. Physical spacetime discreteness (repudiation of physical infinity)
2. Order is a more primitive organising principle for physics even than space and time: the spacetime ``causal'' order--of all continuum spacetime structure--survives in the deep theory.

Precedence order and Discreteness: a marriage made in heaven

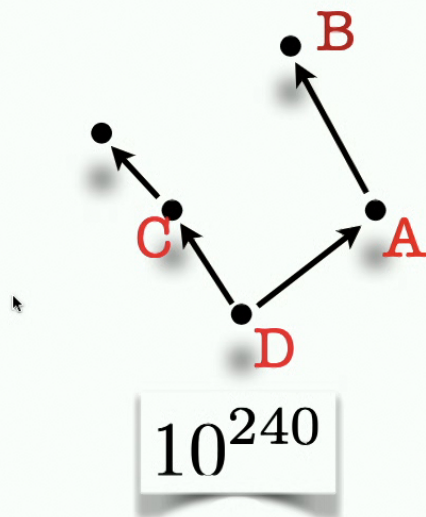


3. The path integral furnishes a framework for quantum theory, an alternative to the canonical "Psi" framework: quantum mechanics is a species of measure theory in which the Kolmogorov sum rule fails and is replaced by a "quantum sum rule" (Sorkin).

Discrete order = causal set (spacetime atoms = indivisible events)

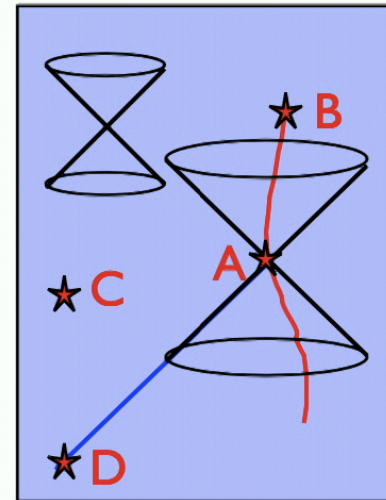
(’t Hooft; Myrheim; Bombelli, Lee, Meyer and Sorkin)

Causal set =
transitive, directed, acyclic graph



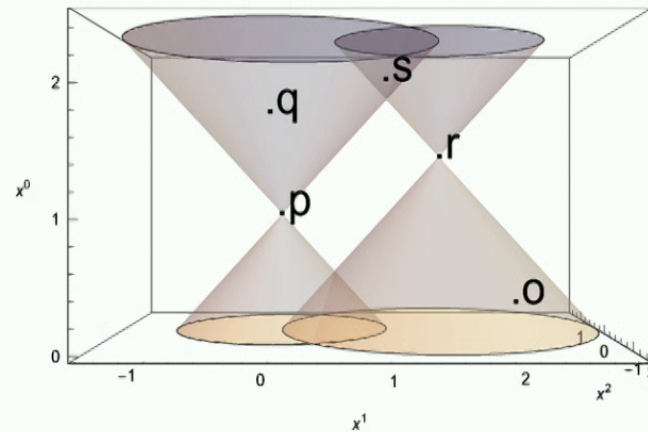
After
↑
Before

Continuum approximation (fluidlike)



Order + Number = Geometry

Partial order



- ▶ Event E_{neur} is composed of a spacetime substrate with some matter degrees of freedom as decorations of spacetime.
- ▶ In causal set theory (CST) this piece of \mathbb{M}^4 is hypothesised to be a continuum approximation to a causal set, a set of spacetime atoms with an **order of precedence**. About 10^{120} of them, uniformly embedded.
- ▶ The order of the spacetime atoms is a partial order: $o \prec r$, $r \prec s$, $o \prec s$, $p \prec q$, $p \prec s$ and there are no other order relations.
- ▶ For the matter of E_{neur} we suppose there are certain decorations on the spacetime atoms.
- ▶ A spacetime atom with its matter decoration is an atomic-event.
- ▶ The **occurrence** of E_{neur} in CST is the **process** of the birth of its spacetime atoms.
- ▶ There are interesting models in which steps in this process are given certain definite probabilities (like in random walk) **Rideout and Sorkin**

Qualities of Experience ↔ Properties of the birth process

The Heuristic again: The birth of the atomic-events that compose E_{neur} in CST correlates with *A having* that conscious experience live, in real time.

- (1) *In the birth process each atomic-event occurs once. The occurrence of an atomic-event is momentary. Immediately an atomic-event occurs, it becomes part of the past.*
Conscious experience has been described as momentary, fleeting and of the now.
- (2) *The birth process is unceasing.*
Conscious experience of time passing has been described as inexorable.
- (3) *The birth process can only be objectively viewed from inside the world, as it happens.*
Conscious experience has been described as live.
- (4) *The birth process can only be viewed from inside the world. The entity having the experience in the world cannot copy and communicate that experience, cannot share it with another entity since to do so would be to create a picture of the process that is external and objective.*
Conscious experience has been described as internal and private.
- (5) *The birth process is objective.*
Conscious experience has been described as indubitable.
- (6) *The birth process is the experiencing.*
Conscious experience has been described as immediate (un-mediated).

Various Hard Problem Issues in the light of the Heuristic: I

- ▶ **Consciousness in the Block**

The answer to the Wittgenstein-to-Anscombe type question, "What would it look like if it looked as if our world were a Block Universe?" is, "It wouldn't look like anything because it would all be over."

- ▶ **Something is missing**

The NCC theory is a theory based on concepts of NCC events-as-such. Live experience is the occurrence of the NCC-event. The "something missing" from the NCC theory is the birth process.

- ▶ **The knowledge argument**

Anyone who knows the NCC theory knows the full physical account of the event-as-such *E* that is "A had a conscious experience of seeing a red ball". But one cannot know the physical correlate of *A having* the experience, live and in real time, because the correlate of the having is the partially ordered birth process. Only *A* can view it, experience it, from within, live and as it happens.

Various Hard Problem Issues in the light of the Heuristic: II

► Panpsychism

The Heuristic is sympathetic to panpsychism only to the extent that the birth process is universal to the whole physical world. The question, "Which entities have conscious experience?" is the question, "Which events are NCC-events?" and defines the quest for an NCC theory. For example, a supernova is an event and is composed of atomic-events. The partially ordered birth of the atomic events composing the supernova-event is the occurrence of the supernova-event. The question "Was the supernova that occurred conscious?" is a question that the NCC theory should answer.

► Fundamentalism about consciousness

The partially ordered birth process is fundamental and not emergent in CST. The process cannot be recovered from anything more basic. The NCC theory on the other hand will be constructed using concepts in biology, neuroscience and cognitive science such as neurons, information processing and superfast model fitting.

► How does consciousness interact with physical stuff, particles fields etc?

Conscious experience is the birth process (in the brain) so this question makes as much sense as "how does the birth of a baby interact with a baby?" The process is the creation of the stuff (4D-spacetime-stuff).

Returning to Einstein's epistemology: the partially ordered birth process in causal set theory blurs the boundary between the world of ideas and the totality of sense-experiences. The birth process in CST as its live, dynamic self cannot be situated fully in the world of objective, communicable physical concepts because the births are partially ordered. Though the process is a concept in the theory, it can only be fully apprehended as its dynamic self in the manifold of sense-experiences. It can only be objectively viewed from within. It has to be lived, it has to be experienced to be apprehended. One cannot know, from the outside, **what it is like**.