Title: The origin of arrows of time II

Date: Jun 27, 2016 02:00 PM

URL: http://pirsa.org/16060109

Abstract:

What is physics made up of if not symmetries?

Identification of patterns, conserved quantities

The world is described by equations frozen in time

Pristine dynamics

Immutable truths

Sharp sense of aesthetics

Simplicity

Beauty

Sharp sense of aesthetics

Simplicity

Beauty

One equation to rule them all

Time asymmetry fulfils none of these:

Dissipation
Retarded potentials
Measurement – Non Unitarity

"DIRTY"; UNDESIRABLE IN EQUATIONS

We carefully eradicate signs of time asymmetry from our theories

- Effects usually small or subtle

INITIAL CONDITIONS!!!

It adds up!!

Every time we call initial conditions to get rid of an undesirable arrow of time the pile under the rug gets bigger.

It shows up in the Early Universe

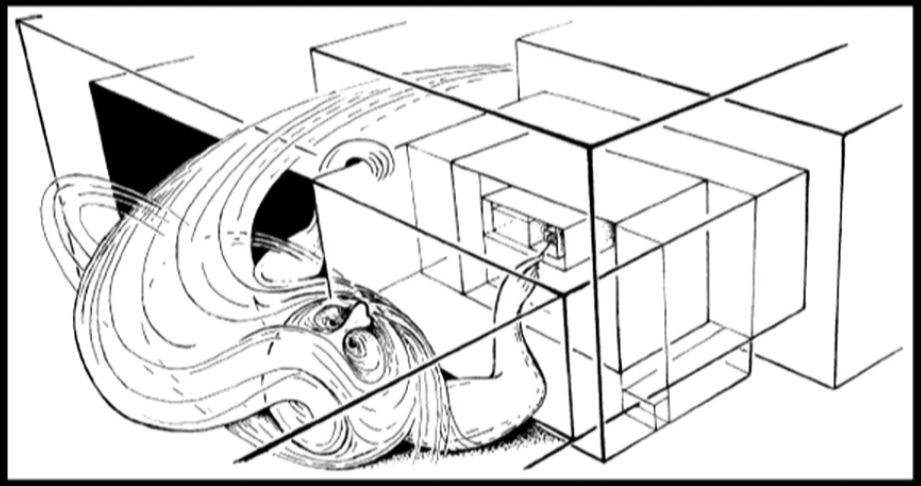
- Cosmologists

Early Universe Entropy:

Gravitational degrees of freedom:
10^{21} per baryon.
Number of baryons: 10^{80}.

$$10^{101}$$

Early Universe Entropy:



Overwhelming low entropy 10^{101}

Multiverse?

Advanced potentials in EM:
Source precedes radiation, not the other way around.

What is the entropy cost of
CONSPIRACY TO CREATE SPHERICAL RADIATION THAT EMITS THE SOURCE?

This is allowed in EM: more low entropy expense for early universe

Pristine Hamiltonian evolution of the wave function:

-Reversal of measurement.

-Reversal of stochastic evolution.

-Measurement is a nuisance.

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Many Worlds

World Mathematics

Trail away behind mathematics
"Go back to Nature"
How does the world look?

World vs. Mathematical Beauty

Questioning our convictions is root in science

What is insistence with global time symmetry?

Is the arrow of time and the passing of time an illusion?

Or is it the deepest clue nature is giving us to the nature of reality?

Maybe theory of the whole Universe needs a new starting point.

What we want:

Cosmology st

if $S(t) < S(t+\delta t)$

then $S(t-\delta t) < S(t)$

$|\psi\rangle \in \mathcal{H}$, $\hat{H}|\psi\rangle = i\partial_t|\psi\rangle$

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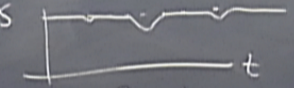
- $\dim \mathcal{H} = \infty$?
- $\hat{H}|\psi\rangle = 0$?

$|\psi\rangle = \sum_t |\text{un}(t)\rangle|\text{clock}(t)\rangle$

- $\dim \mathcal{H}$ = finite
  $\hat{H}|\psi\rangle \neq 0$ ☹



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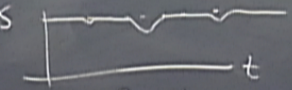

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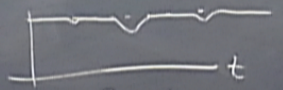

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$-\infty < t < \infty$

Provocation:

"The past hypothesis is unnecessary. It is explained by the gravitational arrow of time."

Argument based on a toy model: (but can be extended to GR!)

Consider a dynamical system generating an unparametrized succession of relational configurations, s..t.:
(1) quantum mechanics as an empirical description for subsystems and
(2) Newtonian mechanics as a classical limit

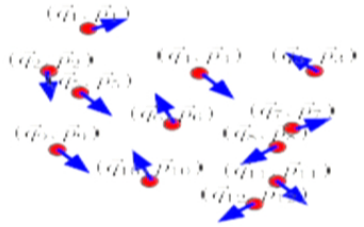
The gravitational arrow of time is the cause of:
(a) the thermodynamic arrow of time in emergent subsystems
(b) the experienced quantum arrow of time (effective collapse)

Relational Universe

"All reference structures are part of the universe, including those that define (local) scale and (local) duration."

⇒ An objective history of the universe can only be narrated as an unparametrized sequence of relational configurations, e.g.

relational data ⇒ equation of state for relational curve evolves through big bang!



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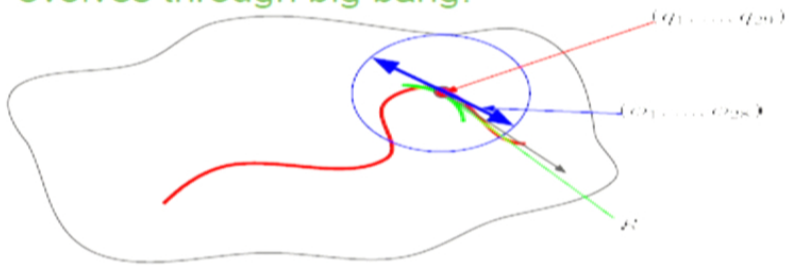


T. Koslowski (UNAM)

T.K. 2016 (in preparation)

2

Gravitational Arrow of Time

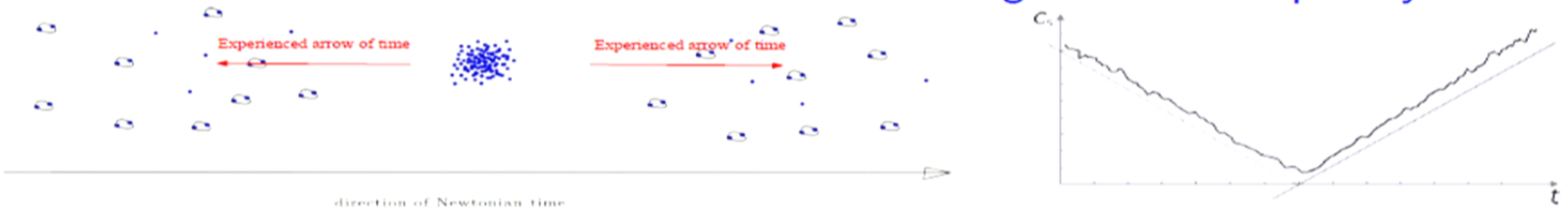
in short:

"The long-term effect of gravity is to cluster matter, forming local subsystems."

more precisely:

There are dynamical attractors on shape space which are characterized by a high degree of clustering (i.e. shapes with high complexity). Generic initial condition, no past hypothesis!

⇒ Gravitational arrow of time := direction of growth of complexity



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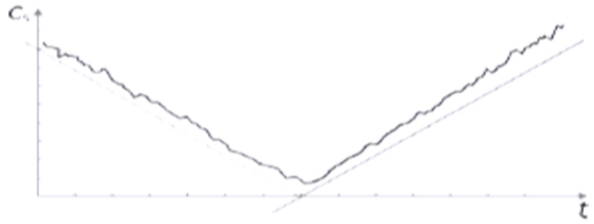

Causing the Thermodynamic arrow of Time

Observations:

1. No external reference structure ⇒ No entropy of the universe as a whole
2. Subsystems use the rest of the universe as background ⇒ subsystem entropy
3. Formation of local subsystems requires growth of complexity (clustering)
4. Interaction of subsystems leads to dynamical equilibration relative to background

$$S(S_1) + S(S_2) \leq S(S_1 \cup S_2)$$

⇒ Second Law emerges dynamically relative to background

Barbour, T.K., Mercati: 1507.06498

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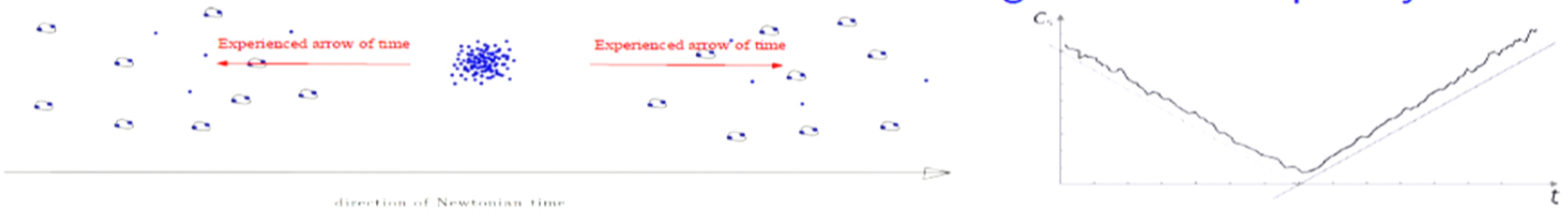

Causing the Quantum Arrow of Time

Consider a quasi-Bohmian dynamical system on shape space:

1. (Bohmian) velocity law: $dq^a = Q^a[\psi; q^a)$ (defines only direction in shape space!)
2. Schrödinger equation: $d\psi = H(\kappa)\,\psi$
3. Auxiliary law: $d\kappa = K[\psi; q^a, \kappa)$ (for extrinsic curvature of curve on shape space)

(exponential mismatch of experienced scale) T.K. 1404.4815 and T.K. 2016 (in preparation)

Record of measurement-like interactions between subsystems leads to effective collapse (analogous to BM)

Effective collapse needs stable local subsystems and their decoherence
⇒ needs grow of complexity

⇒ Quantum Arrow of Time follows Gravitational Arrow of Time

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