# Spacetime from Information Sampling

## Presentism ⟹ Relational lattice of imaginary atoms of space evolving in atomic instants

Hyp1: only the Present exists, as an atomic instant of evolution $\Delta T$

Hyp2: the speed of causality $c$ is invariant in the whole universe

### universe tick $\Delta T$

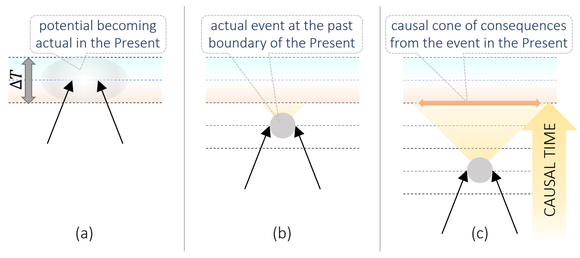
- max rate of change in time
- temporal resolution of events
- time symmetric description within the thickness of each present instant ($\Delta T = 2T$)

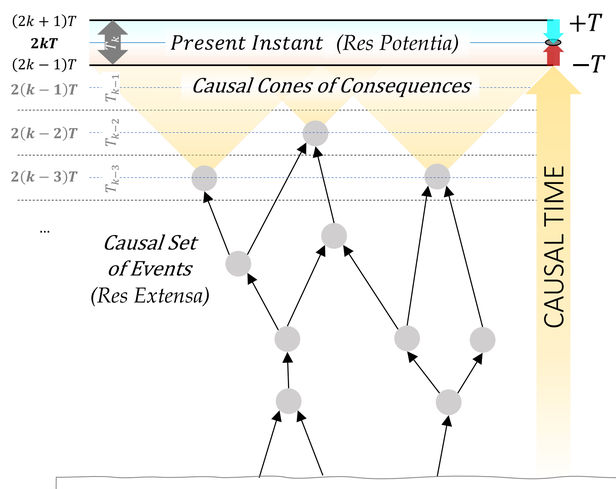
### imaginary step $ic\Delta T$

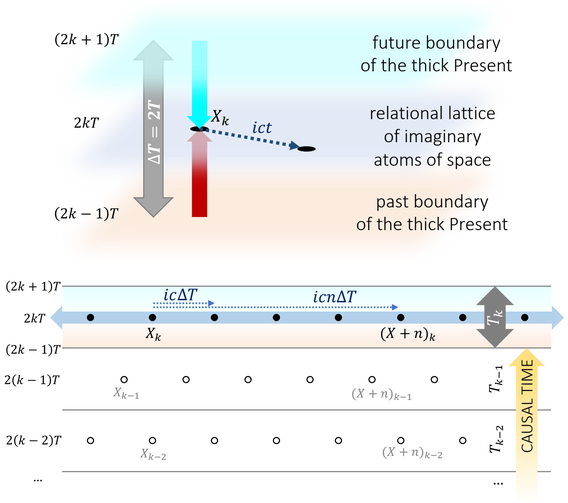
- max rate of change in space
- spatial resolution of events
- imaginary time of motion $i\Delta T$ orthogonal to the causal time

### irreversible events

- ordered in a **causal set** along a discrete axis of causal time
- non existing anymore (only their consequences propagate in the Present)




evolution in atomic instants $\Delta T \Leftrightarrow$ signal with bandwidth $1/\Delta T$
*the info in a continuous band-limited signal is equivalent to the info contained in its discrete samples* (*Nyquist – Shannon sampling theorem*)

## Information ⟹ Sampling of holographically bounded non-locality and undefined causality

Elementary particle as elementary observer

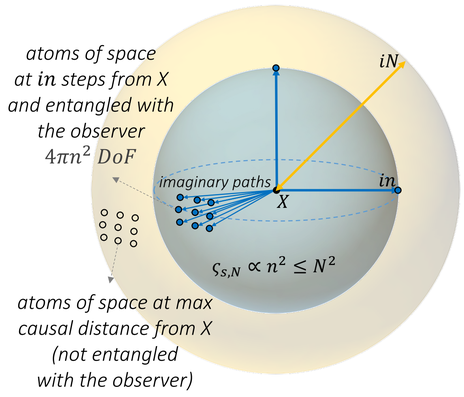
Info sampled through entanglement at the Present from the last collapse event, occurred $N$ ticks before the present instant, at the atom of space $X$

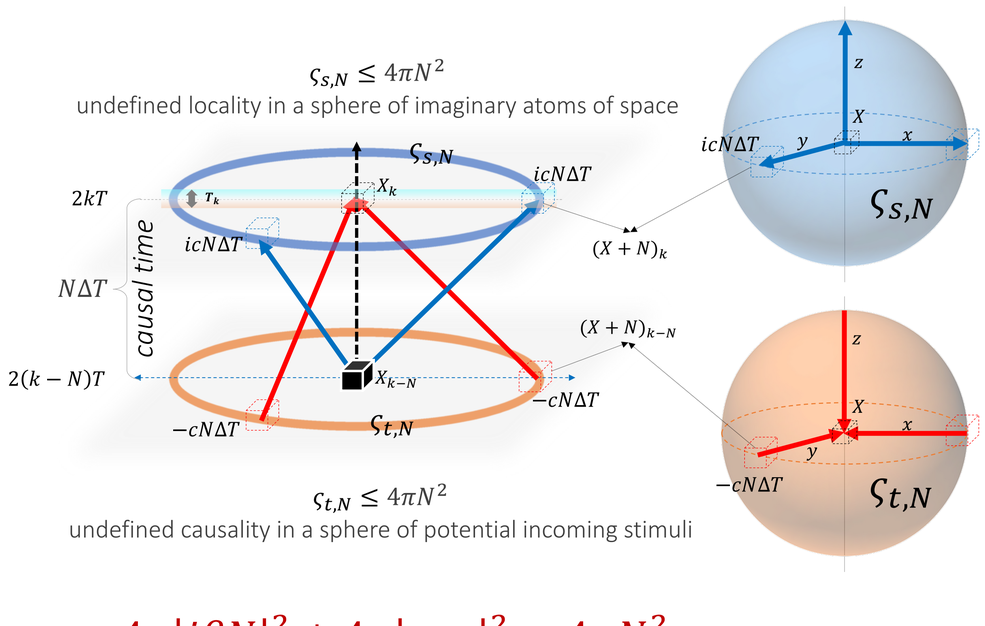
### ➢ info of undefined locality ⇝ $\varsigma_{s,N} = 4\pi|in|^2$

- sampled through entanglement in space
- defined from the most distant atoms of space entangled with the observer (given *ER=EPR*)
- related to the $4\pi n^2$ angular DoF from $X$ and to a relational number of $in = i\beta N$ steps from $X$

### ➢ info of undefined causality ⇝ $\varsigma_{t,N} = 4\pi|-m|^2$

- sampled through entanglement in time
- equivalent to the set of potential events of which the observer at $X$ could have become aware
- related to the proper number $m$ of ticks experienced over the *N* ticks actually occurred in the universe




Hyp3: $\varsigma_{e,N} = \varsigma_{s,N} + \varsigma_{t,N} = 4\pi|i\beta N|^2 + 4\pi|-m|^2 = 4\pi N^2$

## Relativity ⟹ Proper time from a subsampling of the universe ticks between collapses

A particle entangled with $4\pi|i\beta N|^2$ atoms of space after *N* ticks of the universe from its last collapse event samples less info through entanglement in time and experiences fewer proper ticks

$$\varsigma_{t,N} = \varsigma_{e,N} - \varsigma_{s,N} = (1-\beta^2)4\pi N^2 = (1-\beta^2)\varsigma_{e,N} = (m/N)^2\varsigma_{e,N}$$

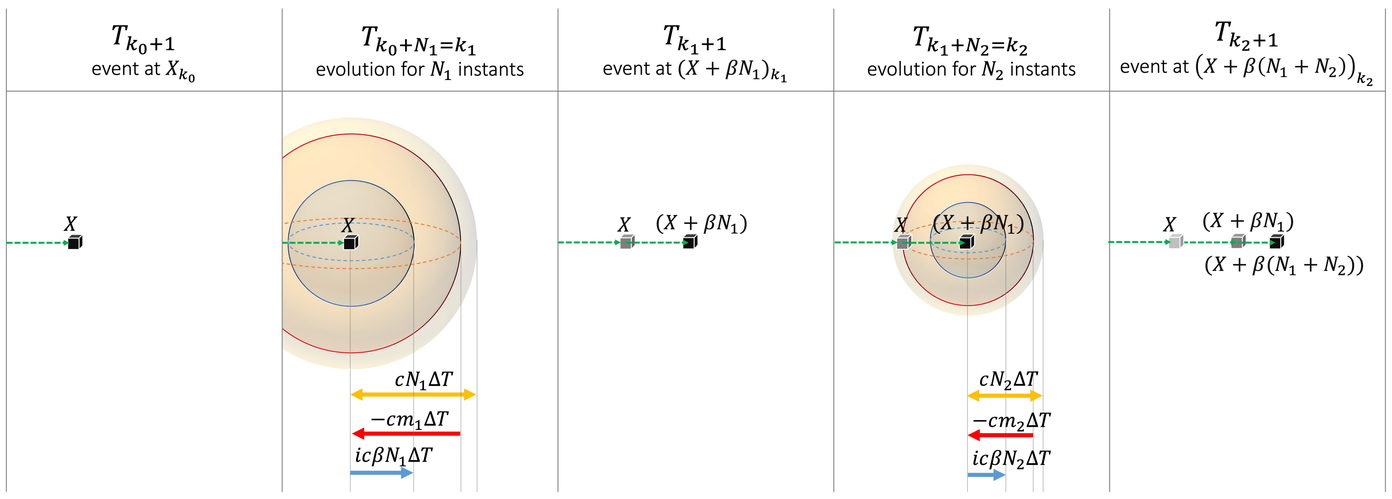
$$\Delta\tau = m\Delta T = \left(\sqrt{1-\beta^2}N\right)\Delta T = \sqrt{1-\beta^2}\Delta t$$

Given an average motion at $v_s = \beta c$ from a series of collapse events, the total proper time is the sum of the proper number of ticks experienced in an undefined causality between the collapse events

$$\Delta\tau = \sum_j (m_j \Delta T) = \sum_j \left(\sqrt{1-\beta^2}N_j\Delta T\right) = \sqrt{1-\beta^2}\Delta t$$

A clock with a period of evolution $\Delta t_0 = N\Delta T$ when at rest has a dilated period $\Delta t_s > \Delta t_0$ when moving at average speed $v_s = \beta c$

$$\Delta t_s = \frac{N}{\sqrt{1-\beta^2}}\Delta T = \frac{1}{\sqrt{1-\beta^2}}\Delta t_0 = \gamma\Delta t_0$$




Evolution of a particle between 3 successive events of collapse. Each panel represents a snapshot of space at a given instant $T_k$. We highlight the atom of space where the particle is located at the different collapse events (*cubes*), the particle's world-line (*green dashed arrow*), the information of non-locality and undefined causality sampled between the event of collapse (*blue and red shaded spheres*), as well as the total information sampled (*yellow shaded sphere*). We note that events and world-lines do not exist in the Present and are shown in the figure for illustrative purpose.

## Outlook ⟹ Matter particles and curved spacetime from entanglement in time and space


Dirac and Einstein

$$p_{ST} = m_0 c + ip = p_T + ip_S$$

$$\psi = (R/cT)e^{-iS/\hbar}$$

$$(-p_{ST}{}^* c) = (\hbar/T)\partial \ln\psi$$

$$|p_{ST}\rangle/|p_{ST}| = |\varepsilon\rangle = \alpha|\odot\rangle + \beta|\leftrightarrow\rangle$$

$$\begin{cases} |\langle\odot|\varepsilon\rangle|^2 = \alpha^2 = \varsigma_{t,N}/\varsigma_{e,N} = \wp_e^T \\ |\langle\leftrightarrow|\varepsilon\rangle|^2 = \beta^2 = \varsigma_{s,N}/\varsigma_{e,N} = \wp_e^S \end{cases}$$

$$\wp_e^T + \wp_e^S = 1 \Leftrightarrow \pi\acute{\alpha}\nu\tau\alpha\ \acute{\rho}\varepsilon\tilde{\imath}$$


Plato and Heraclit

### ...what about Quantum Gravity?

curvature from a local non-hermicity

- asymmetric tunneling probability at a given atom of space towards a massive object
- Curvature ⟺ increased entanglement in space
- gravitational time dilation from a reduction of the possible local entanglement in time

inertial & gravitational mass ⟺ entanglement in time


A FEW REFERENCES

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