

ON THE ROAD TO UNIFICATION

$$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} + \Lambda g_{\mu\nu} = \kappa T_{\mu\nu}$$

MOTIVATION.

Thermodynamics

change in internal energy

change in entropy

S never decreases

$$\Delta E = T \Delta S - W$$

heat

temperature

W
work done by or on the system

COINCIDENCES?

$$\Delta M = \frac{1}{8\pi} k \Delta A - W$$

surface of gravity

A never decreases

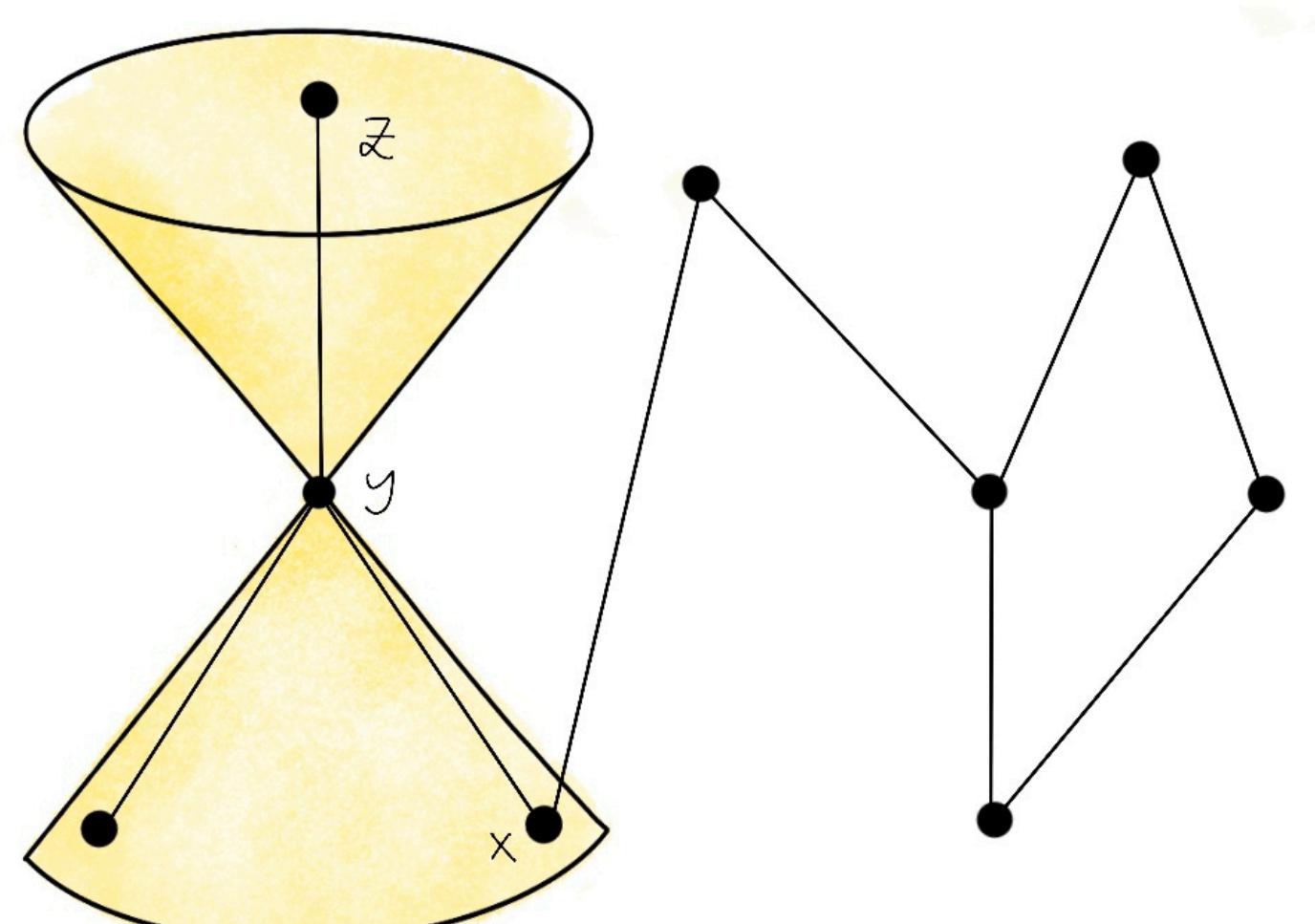
change in mass

change in the horizon area

Classical thermodynamics properties are the result of atomicity of matter, black hole thermodynamics hints toward granularity of spacetime

PROPOSAL.

Causal Set Theory



The microstructure of spacetime has two ingredients:

1. DISCRETENESS:
spacetime at planck scale is granular

$$\ell_p = 10^{-33} \text{ cm}$$

2. CAUSALITY:
the speed of light sets the limit of information transfer and so of cause/effect relations

PREDICTION.

The Universe is accelerating its expansion → an extra term to Einstein equation is added

PLANCK UNITS
the four universal constants c (speed of light), \hbar (reduced planck constant), K_B (boltzmann constant), G (gravitational constant) $= 1$



$$\Lambda = 10^{-120}$$

Λ cosmological constant
energy density for empty spacetime
repulsive force that counteracts the gravitational attraction holding matter together

$$\delta \Lambda = \pm \frac{1}{\sqrt{\text{Volume}}}$$

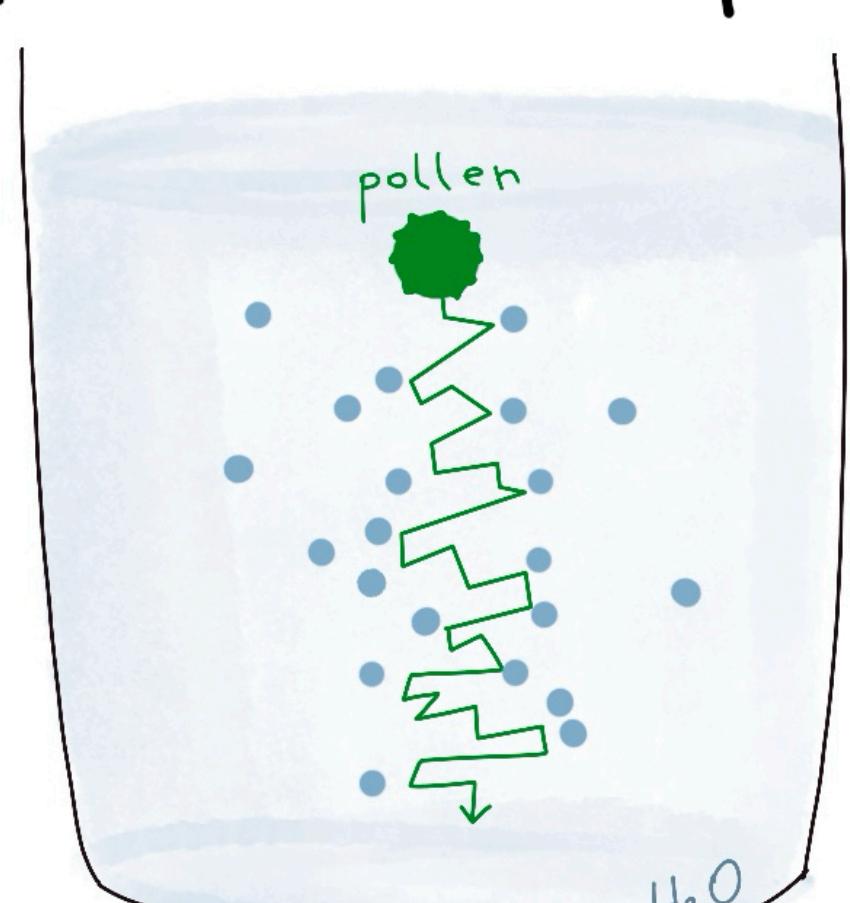
CAUSAL SET THEORY

Λ has quantum fluctuation around zero
→ Heisenberg uncertainty principle between Λ and spacetime volume

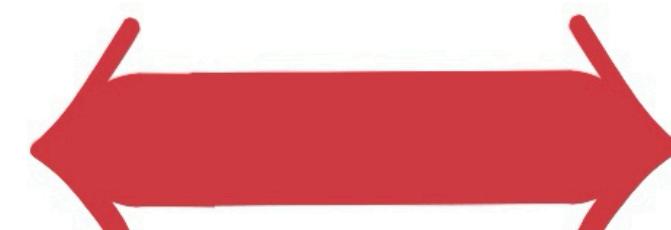
OPEN QUESTION.

Can we find signatures of discrete spacetime?

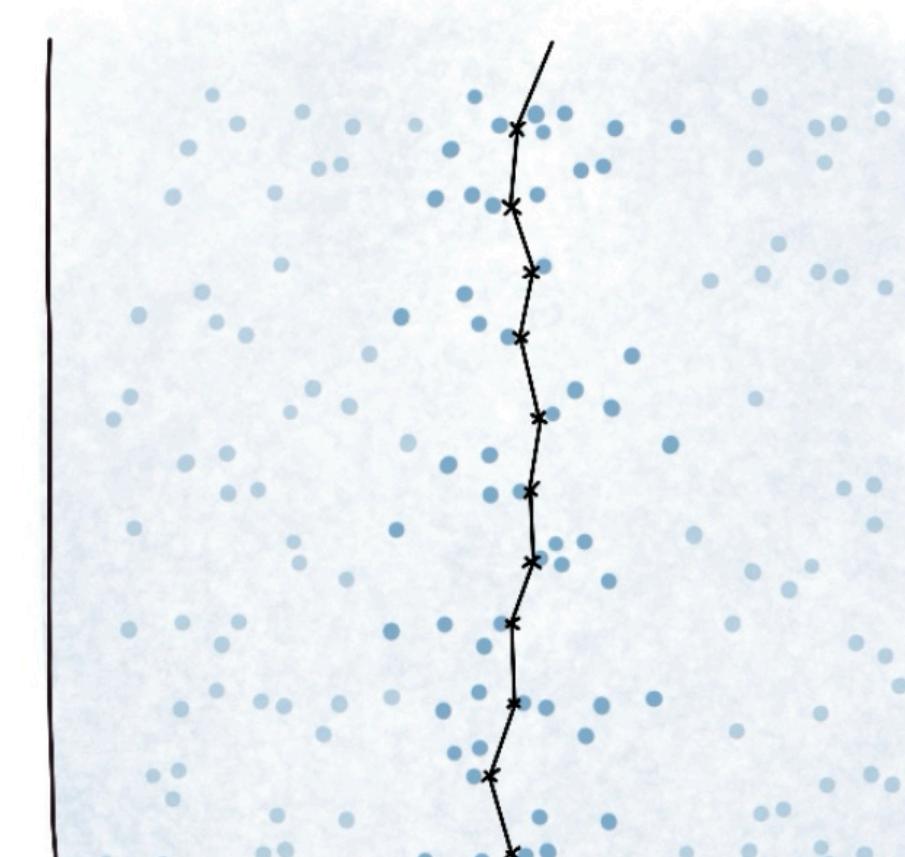
BROWNIAN MOTION



The pollen is jiggling about since it is bombarded by the microscopic molecules of water.



SWERVES



The atomicity of spacetime on planckian scale affects matter moving through it over long distances

GRANULARITY reveals itself on larger things