Gravity and Particles

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Consider

General Relativity

Gravitational fields have a relative existence.

Information is lost inside a Black hole

?

At the beginning of time

Quantum Mechanics

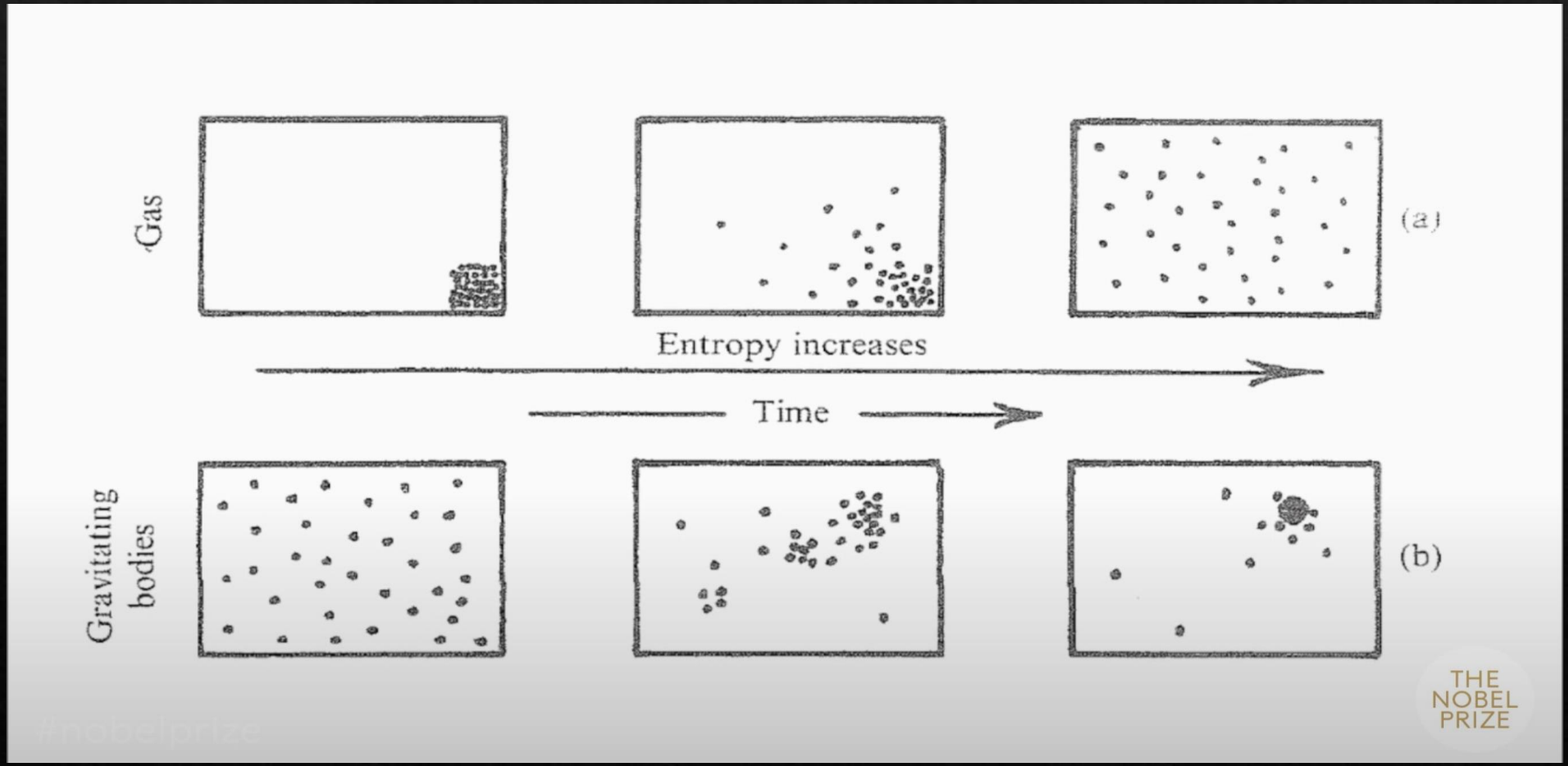
1

Information loss inside the back hole violates this conservation.

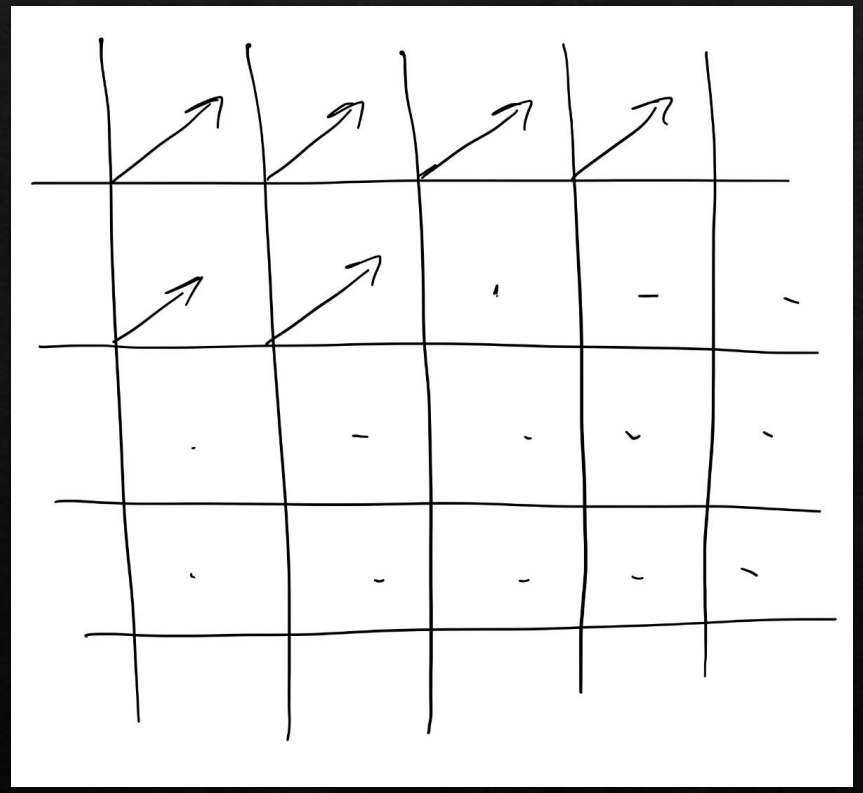
Conclusion:

QM must be Modified in a way that takes mass into account

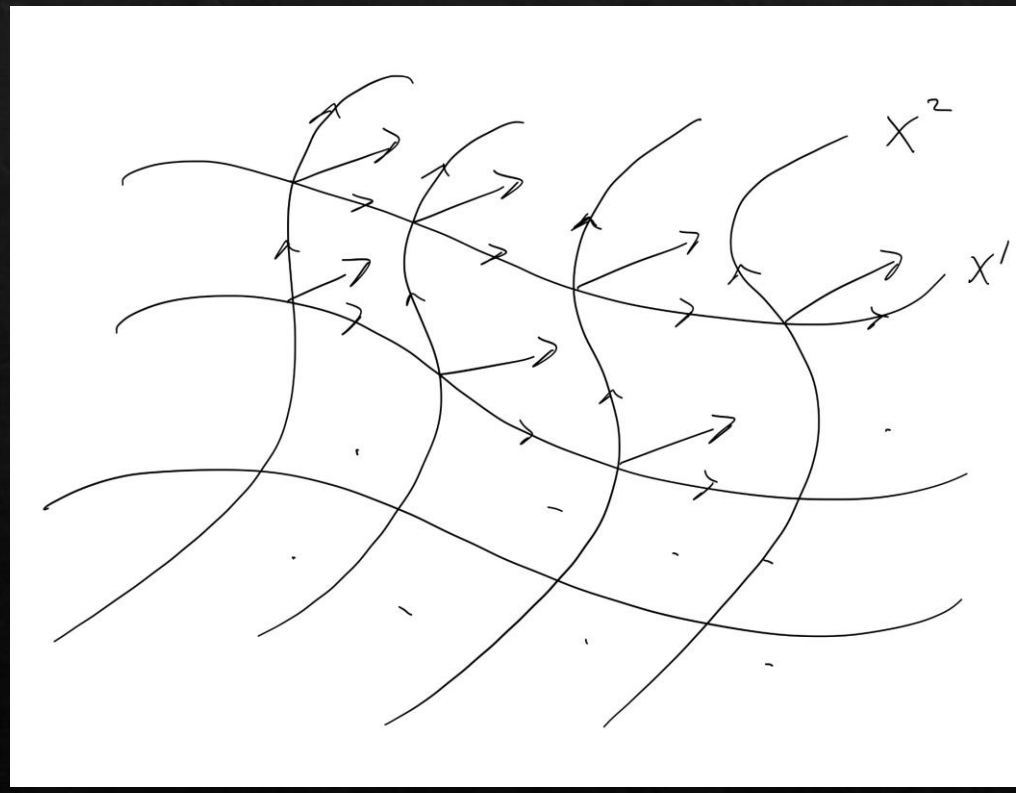
Large Things and Small Things



Space V. Curved Space



$$\frac{\partial V_m(x)}{\partial x} = 0$$



$$\frac{\partial V_m(x)}{\partial x} \neq 0$$

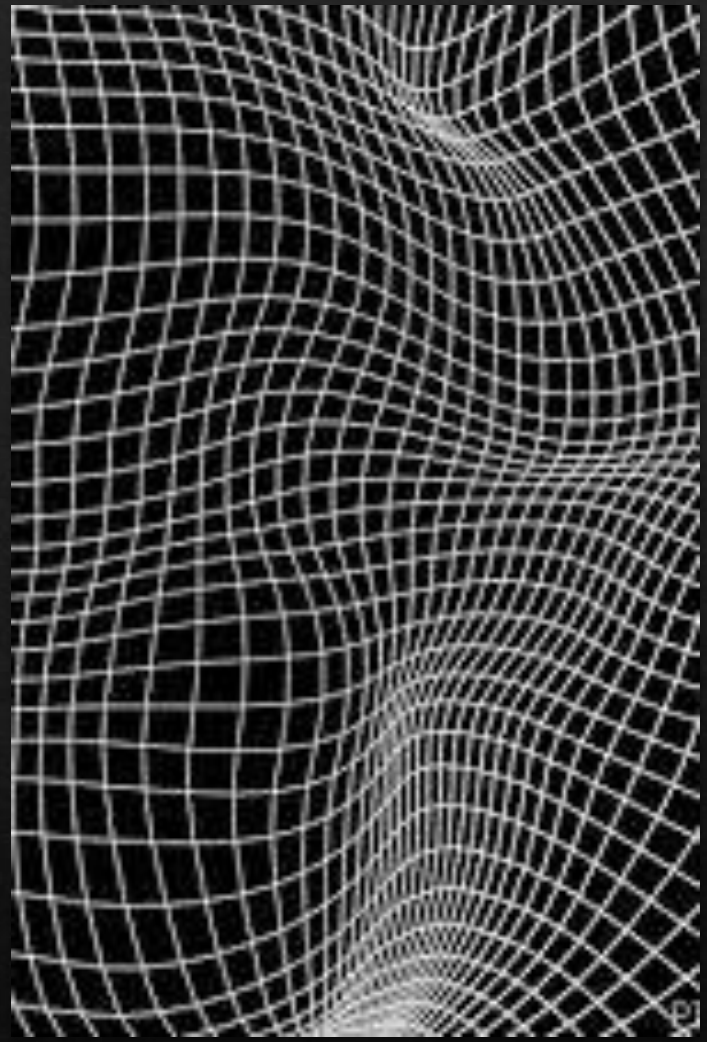
Curved Space and spacetime

$$ds^2 = g_{mn}dx^m dx^n$$

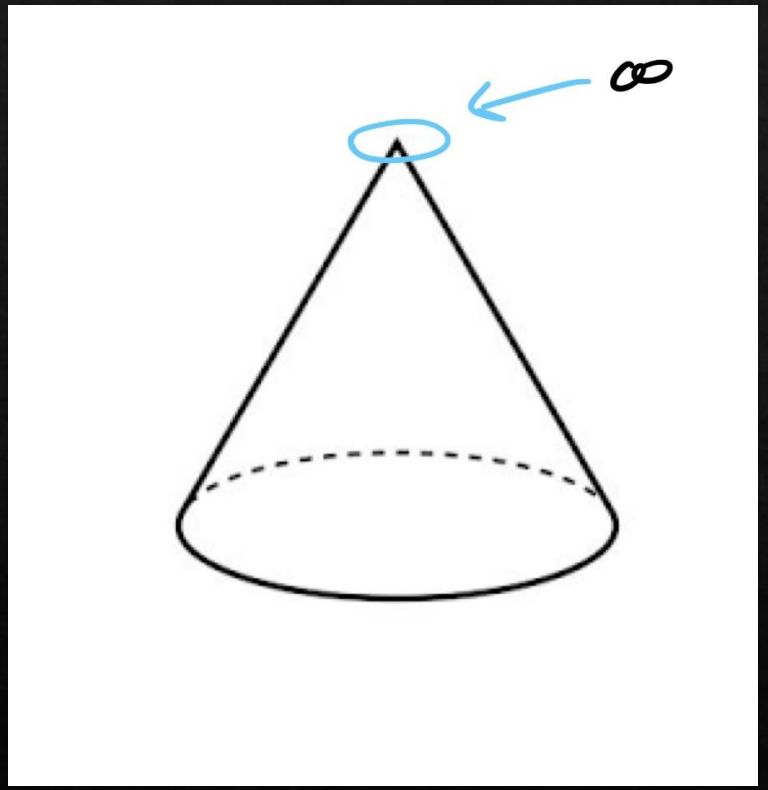
$$ds^2 = \delta_{mn}dx^m dx^n$$

$$d\tau^2 = \eta_{\mu\nu}dx^\mu dx^\nu$$

$$d\tau^2 = g_{\mu\nu}dx^\mu dx^\nu$$



Obstruction



Motion of Particles in G Field

- *Geodesics, the particles move on the simplest type of way.*
  - *Flat spacetime: Straight Line*
  - *Curved spacetime:*

    Orbit of a particle in spacetime

$$\frac{d}{d\tau}\frac{dx^{\mu}}{d\tau} + C^{\mu}_{\nu\sigma}\frac{dx^{\nu}}{d\tau}\frac{dx^{\sigma}}{d\tau}$$

Einstein

- So, how does energy and momentum curve space?
- 2 things
  - Curvature caused by E and P (pnot, p)

$$G_{\mu\nu} = kT_{\mu\nu}$$

    - Total energy and momentum are not the same in all frames
    - Gravity/Spacetime Curvature = Mass-Energy of Matter
  - What geometry does to the particle
    - Geodesics

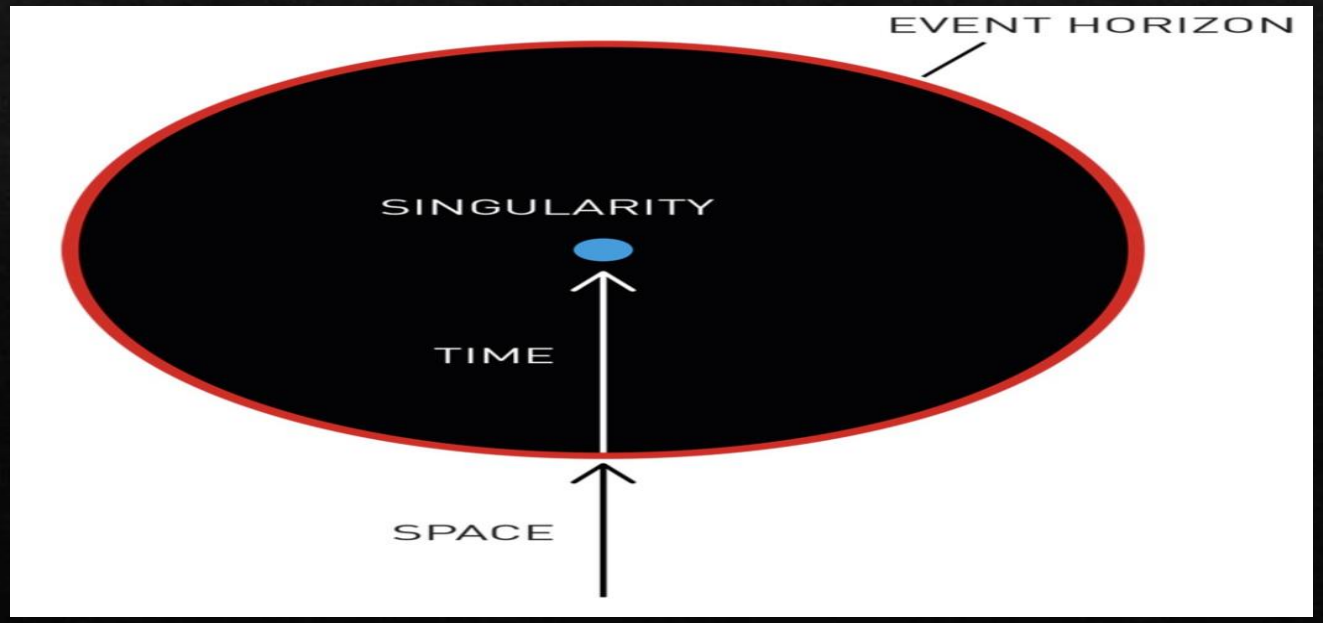
Curved Spacetime (Spherically Sym. Mass)

- r = 0, Singularity
- r = 2GM/c^2 Point of no Return (event Horizon)

$$ds^2 = \left(1 - \frac{2GM}{c^2 r}\right) c^2 dt^2 - \frac{1}{1 - \frac{2Gm}{c^2 r}} dr^2 - r^2 (d\theta^2 - \sin^2 \theta \, d\varphi^2)$$

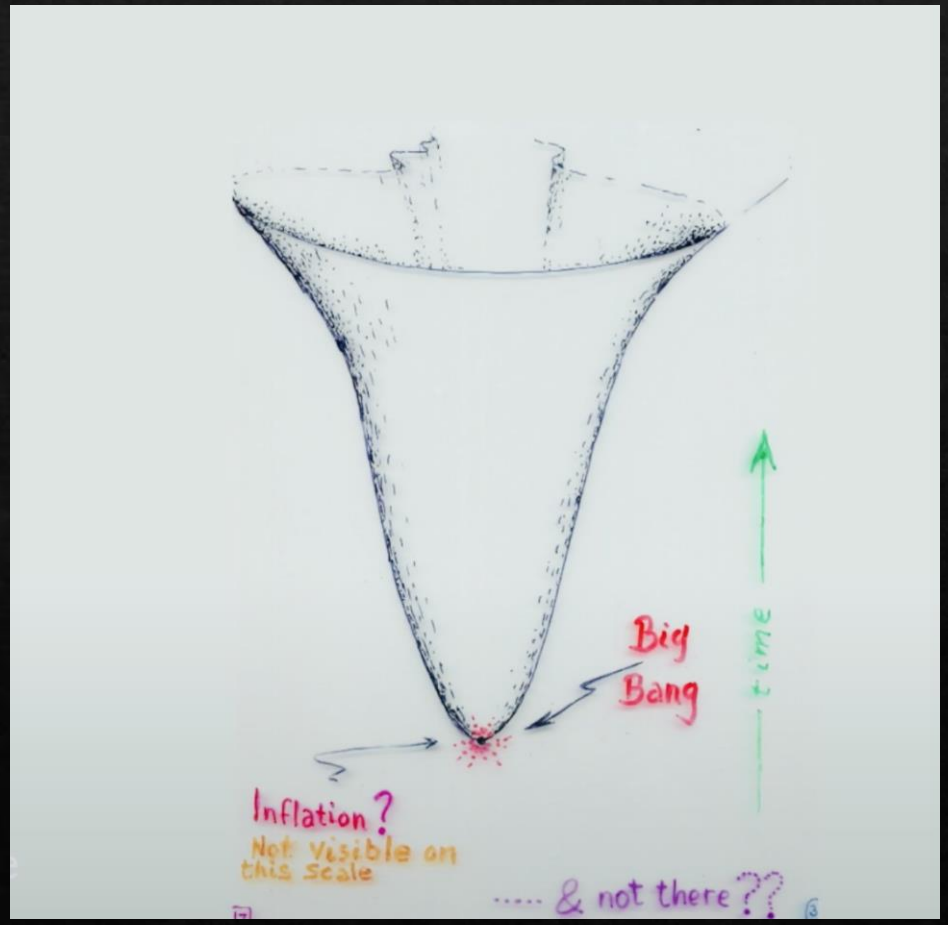
Black holes

- By GR the formation of Black holes must be seen as a natural process in the development of the universe.
- At the singularity gravity becomes infinitely strong



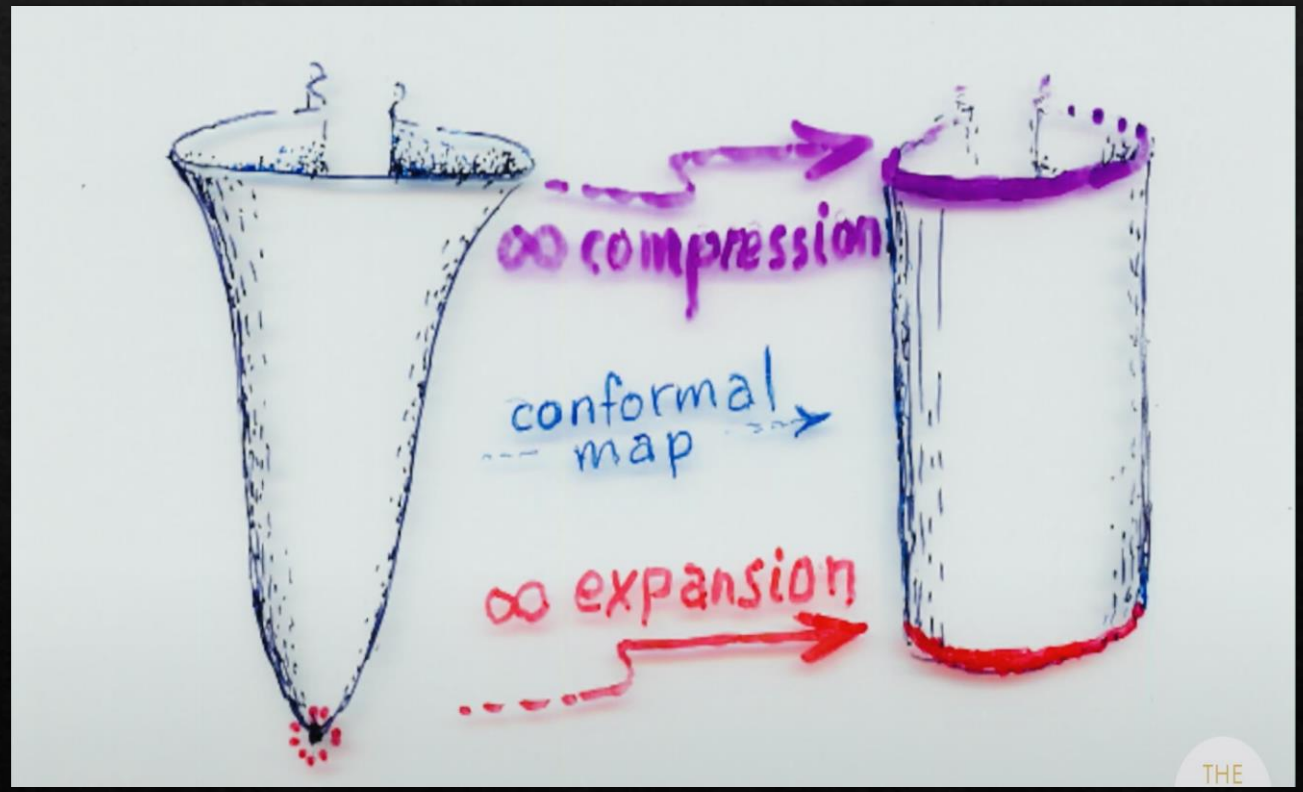
Singularity in Spacetime

- Penrose
  - General circumstances, in the past if you have some kind of diverging ray, some kind of expansion in the universe then you couldn't avoid having this singular state in the early universe.
  - One component of g blows up
  - Regularize by changing to a conformal geometry

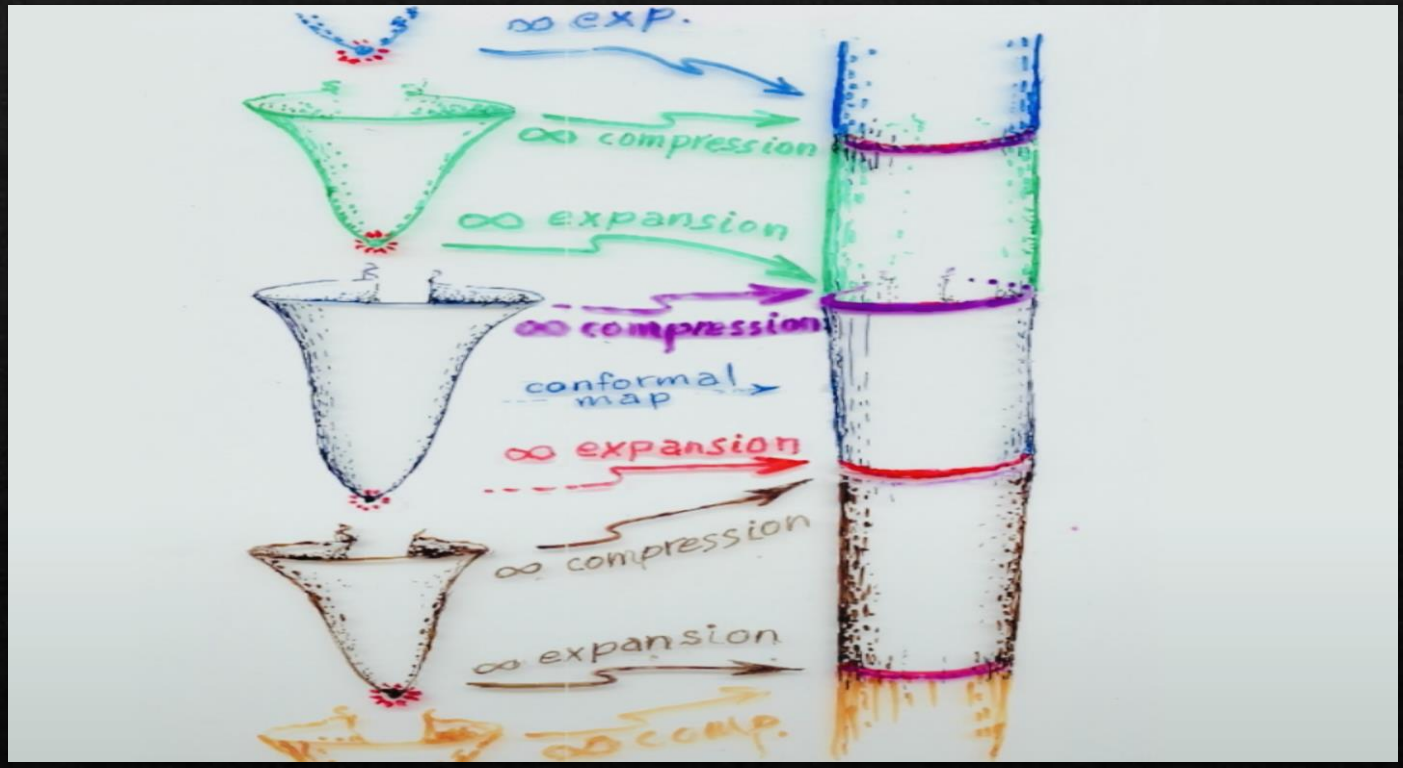


Mapping

- Conformal geometry maps the metric at the end of one Aeon to the metric at the beginning of the next.



Multiple Aeons



- Red = distant supermassive BH's
- Top right Blue = Closer to us withing our past region, something not as massive but still very massive

- Notice the inhomogeneity of the picture

- The G Bodies are clumped together in the color(mass) but also clumped together in where we see them