Holography, Gauge-gravity Connection and Black Hole Entropy

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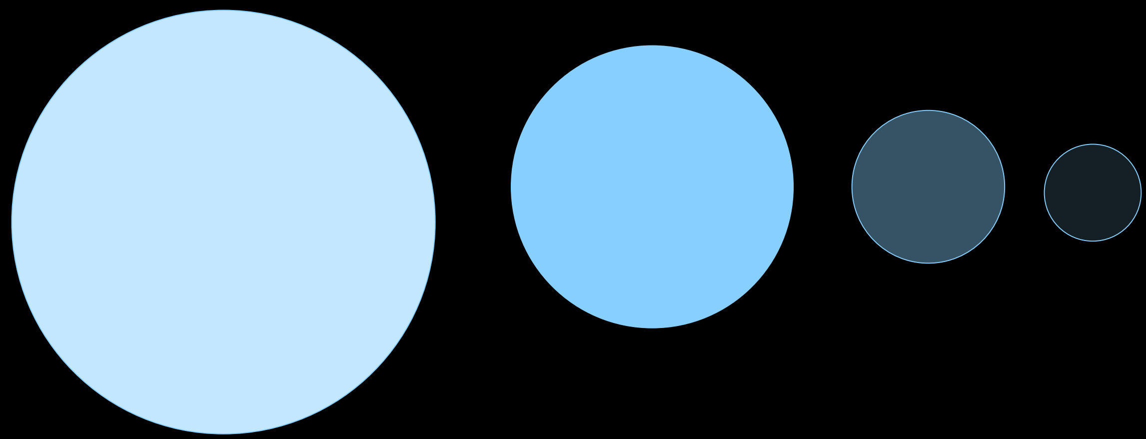
Black holes : Extreme gravitation at work → what lies beyond the 'horizon' observationally unknown



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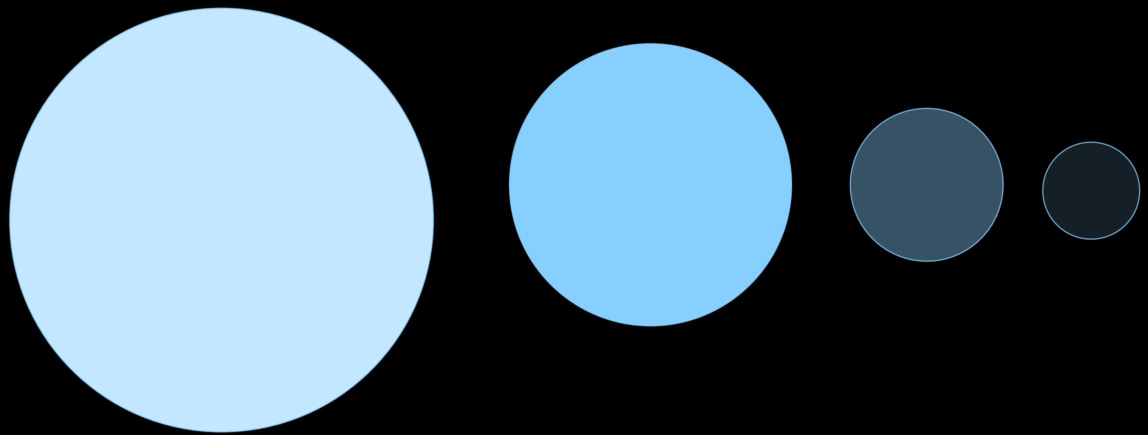
Inaccessibility $\Rightarrow$ apprehensions $\Rightarrow$ Turn to theory



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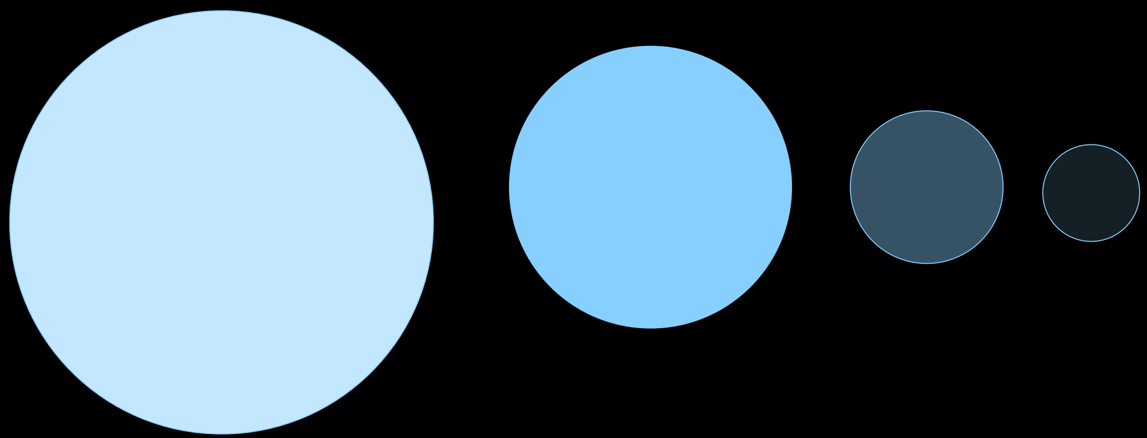
Black Holes from Newton's law ? **Dark stars** Mitchell 1774; Laplace 1789



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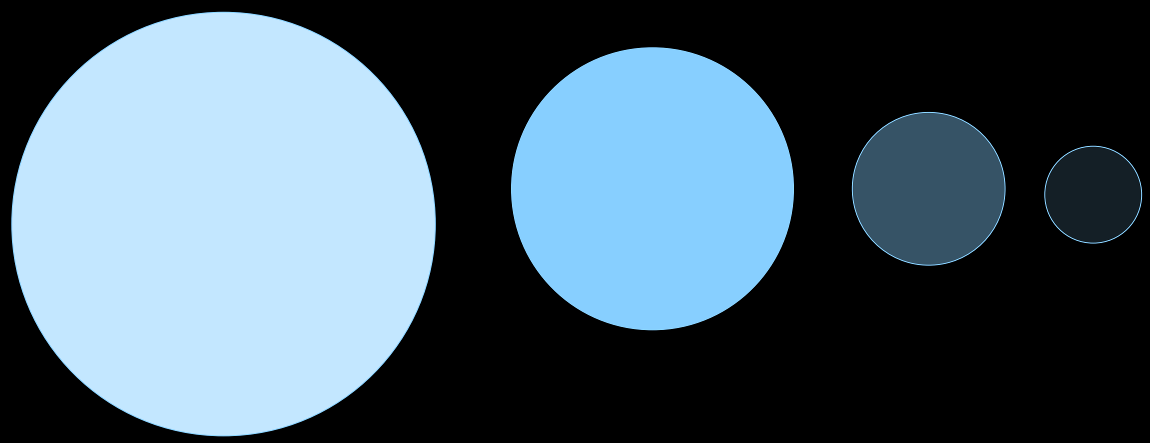
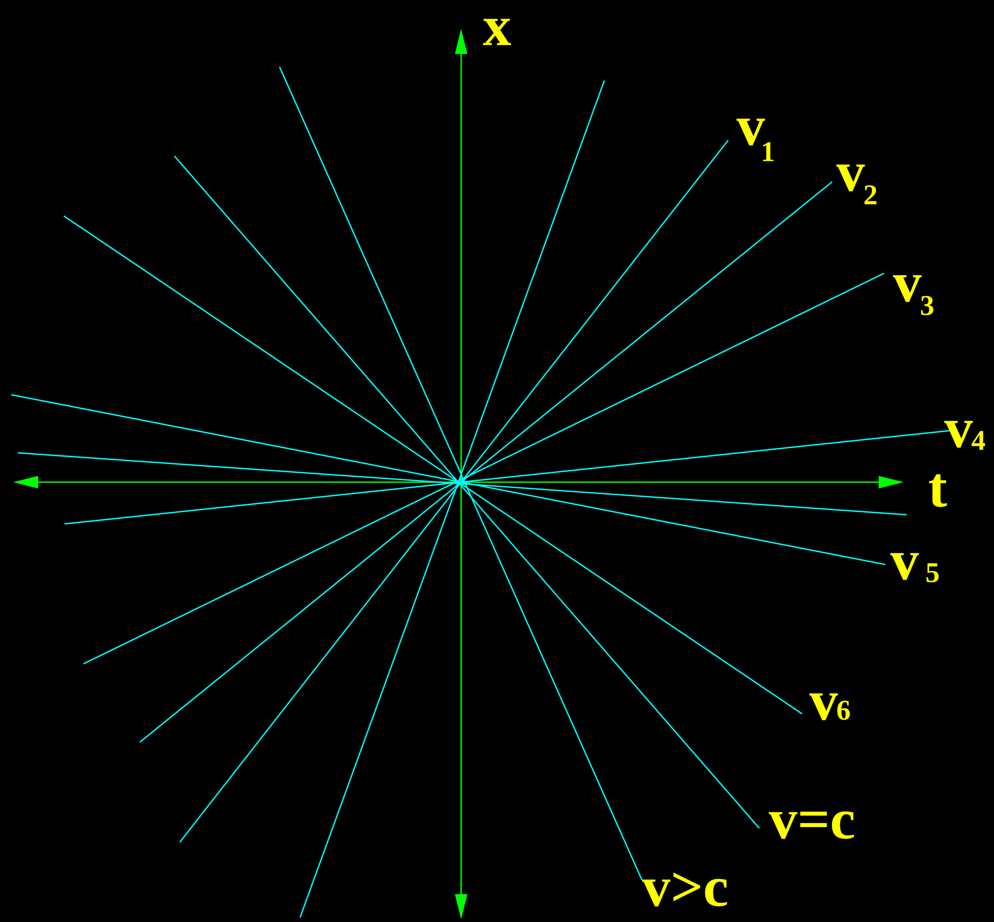
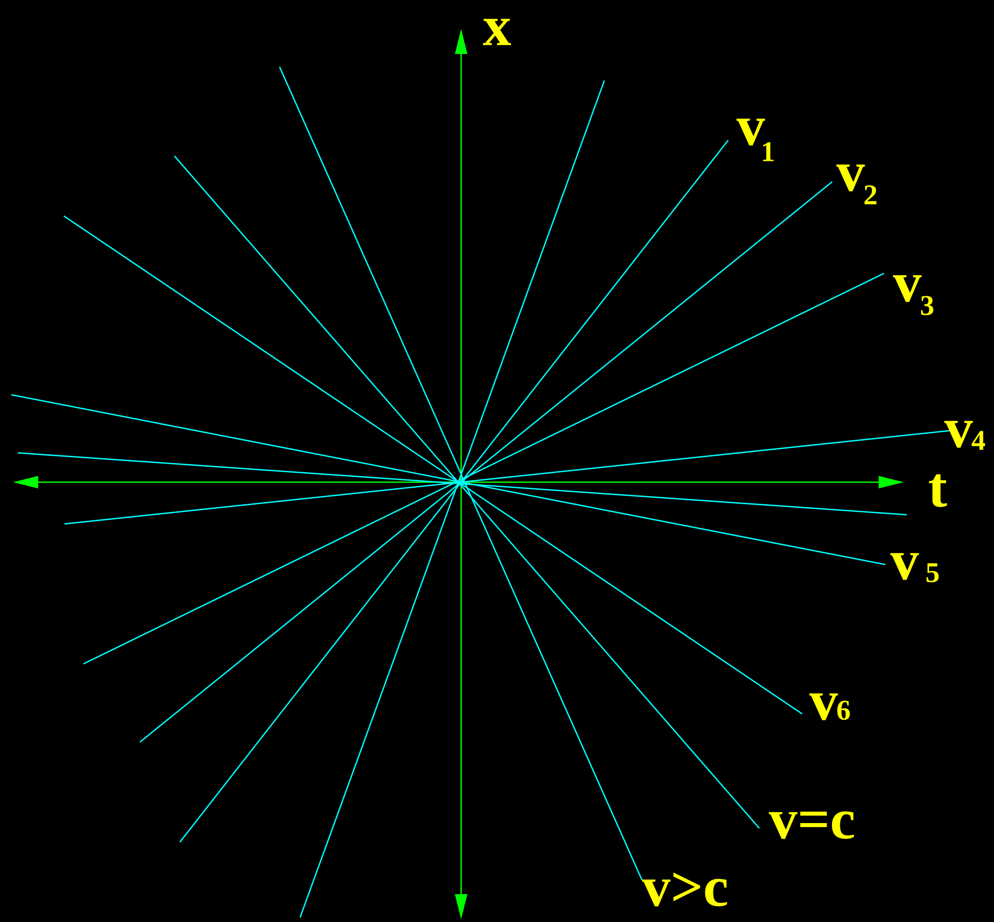


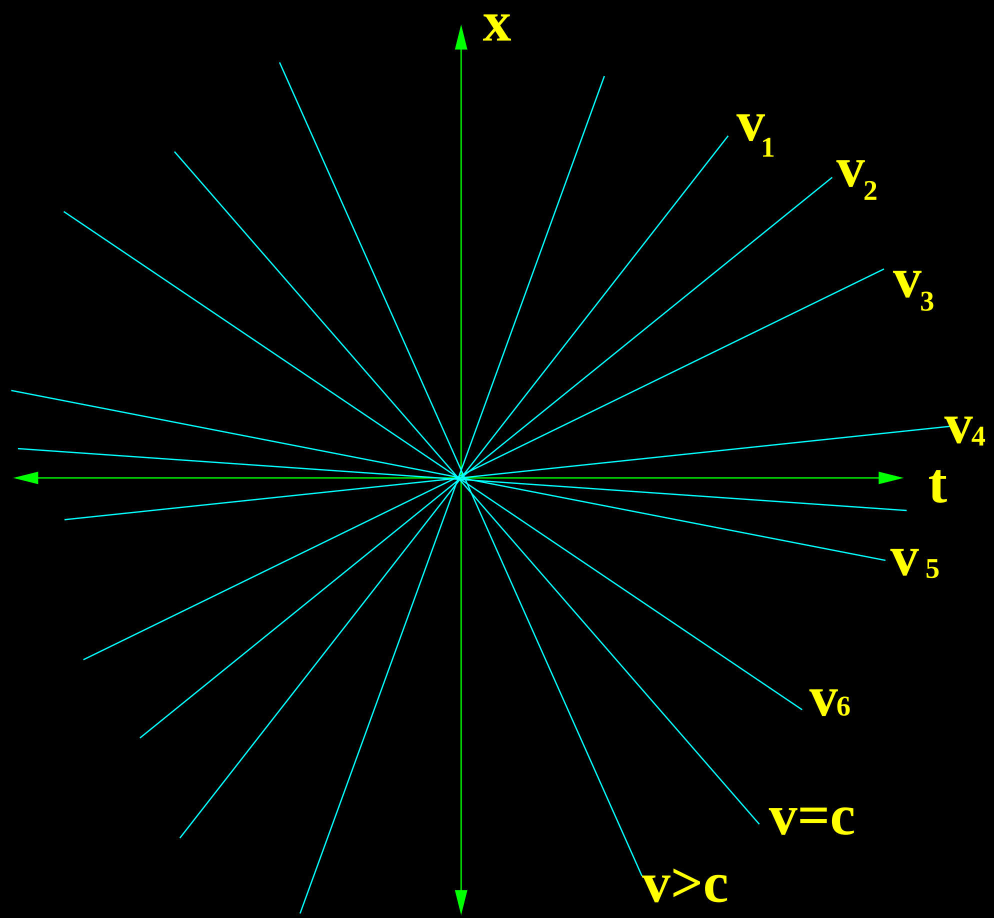
c is very high; but did Newton have reason to believe that nothing could travel faster than c ?


x
v1
v2
v3
v4
t
v 5
v6
v=c
v>c



All velocities are relative : ⇔ Travel at c or even higher is not barred!

Galilei 1600s



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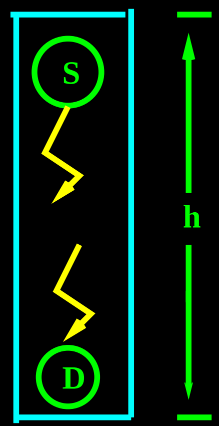
Galileian relativity : $c \longrightarrow c \pm v \Rightarrow$ **No dark stars!**

SR gravitation ?

Ruled out by thought-experiments! 'Happiest thought of my life Einstein 1908



REBKA−POUND−SNYDER EXPT

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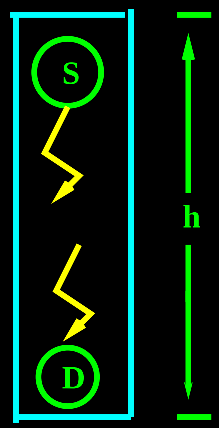

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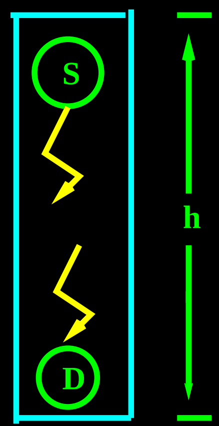

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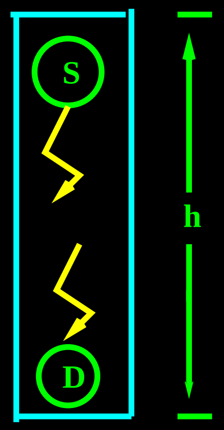

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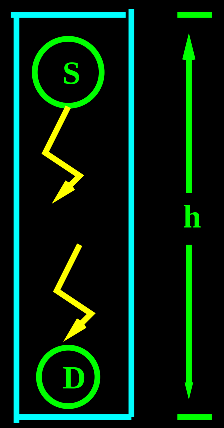

REBKA–POUND–SNYDER EXPT

$$\omega_D = \omega_S \left(1 + \frac{\Delta\phi_{SD}}{c^2}\right)$$

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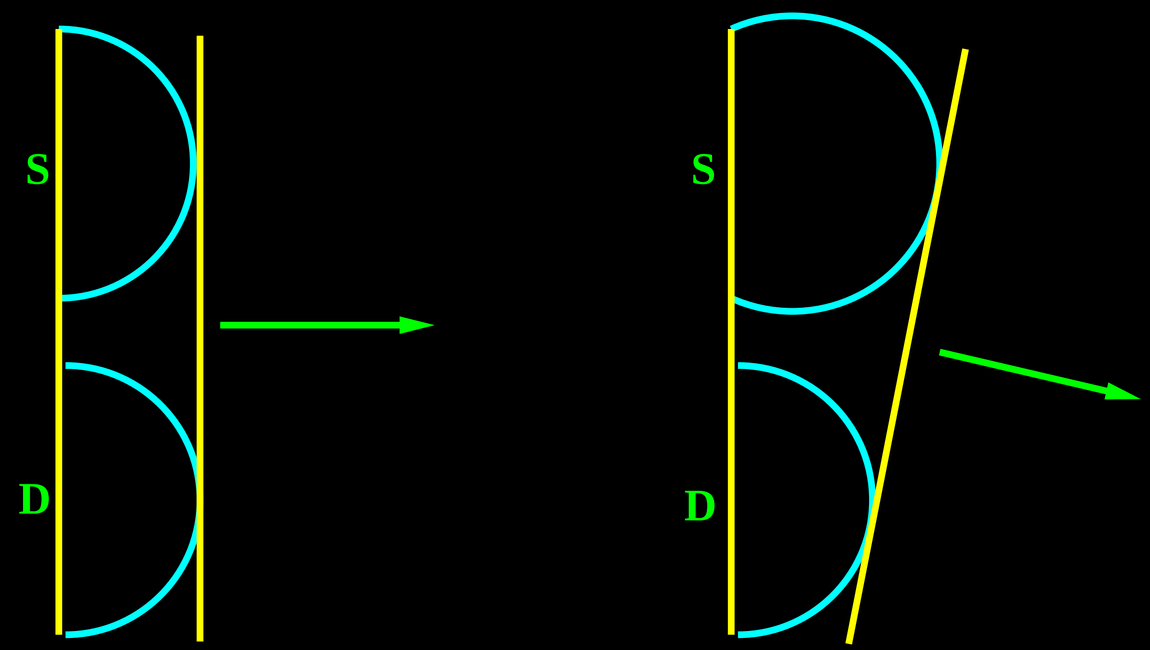

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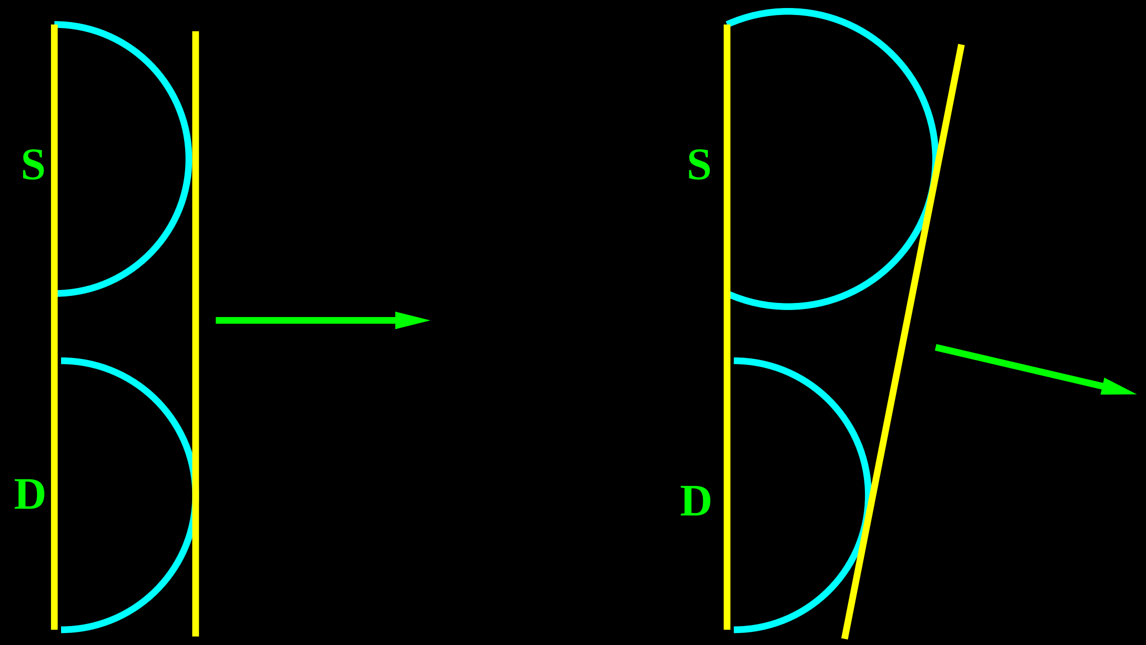
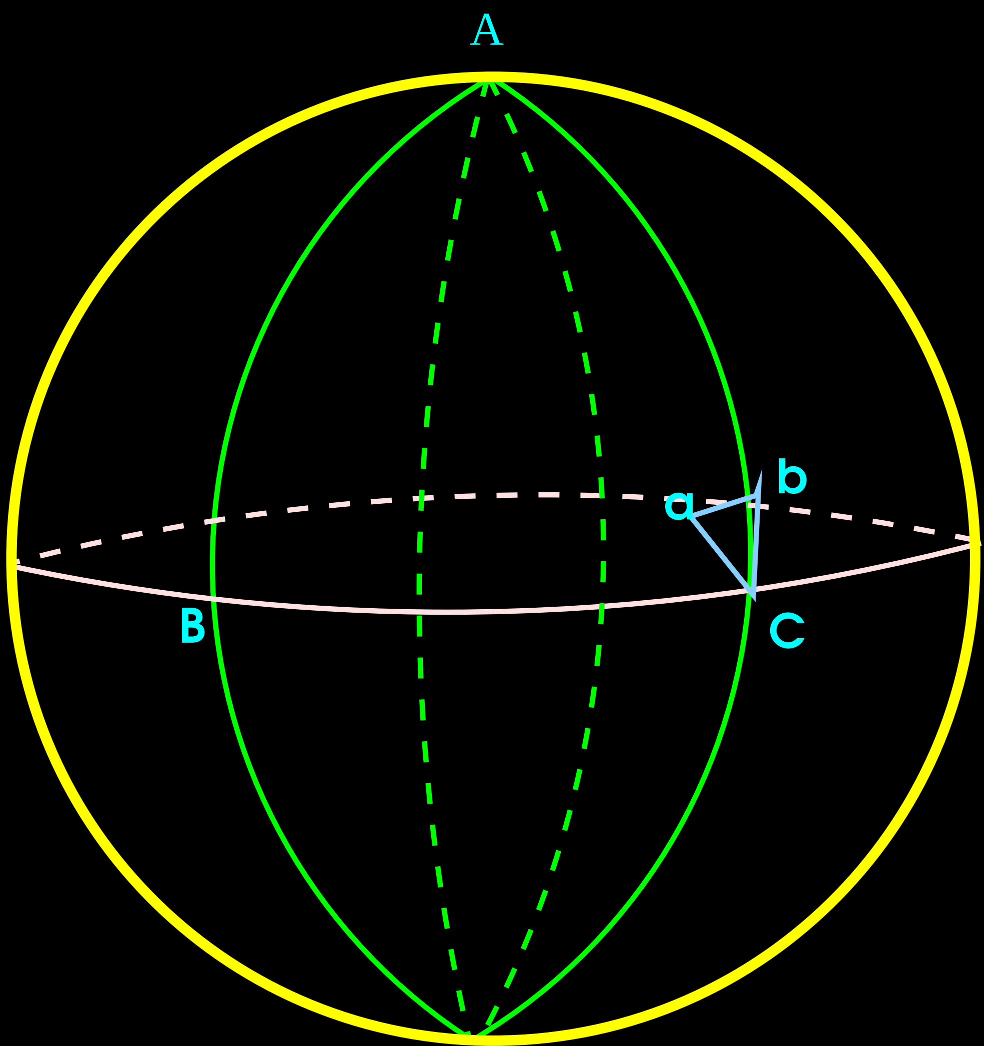


Spacetime is curved!

Toy example of curved space: geography globe



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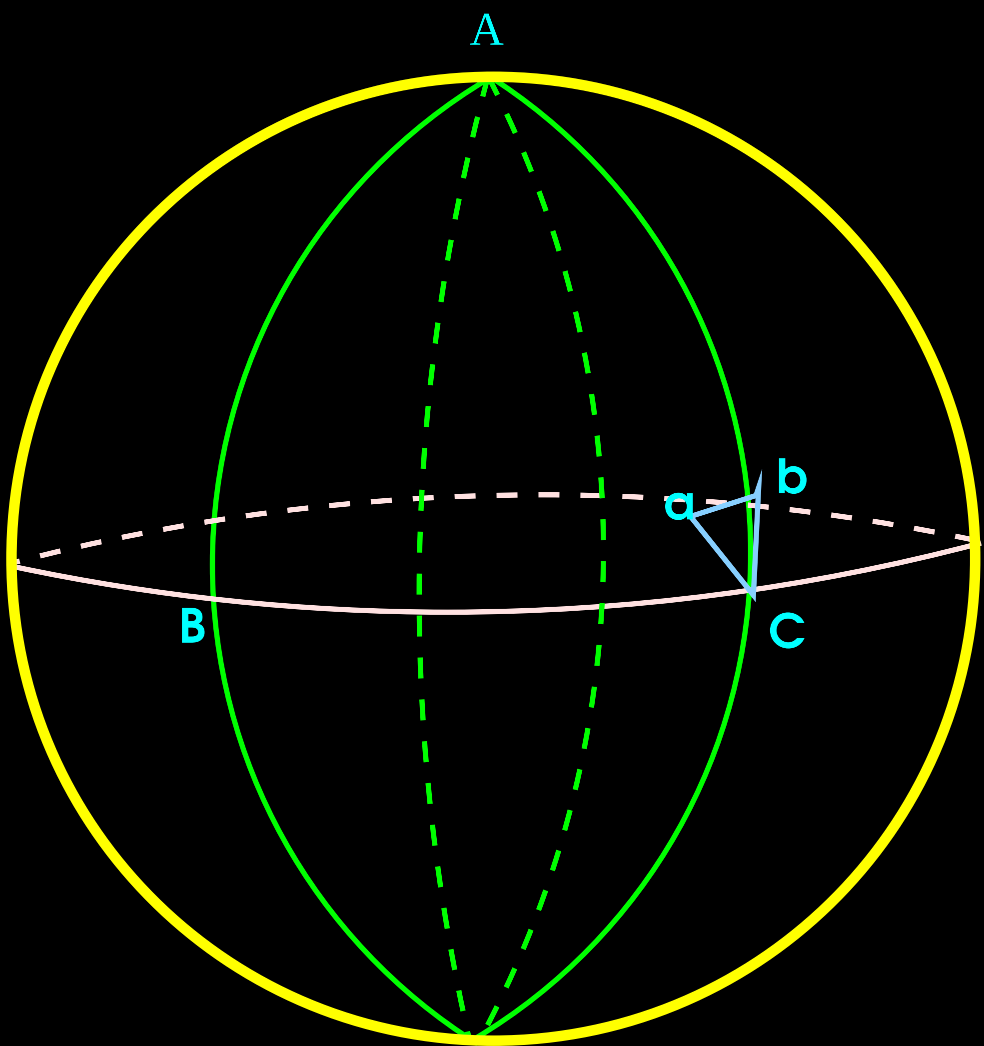
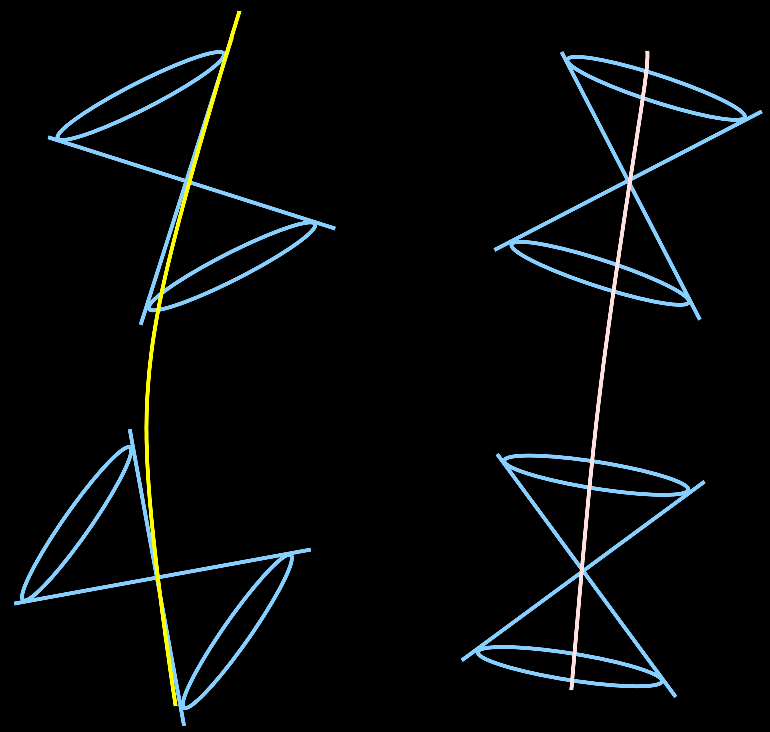


Non-Euclidean in the large, but locally Euclidean

Einstein's GR model of spacetime : Curved but locally Minkowskian $\Rightarrow$ have local light cones



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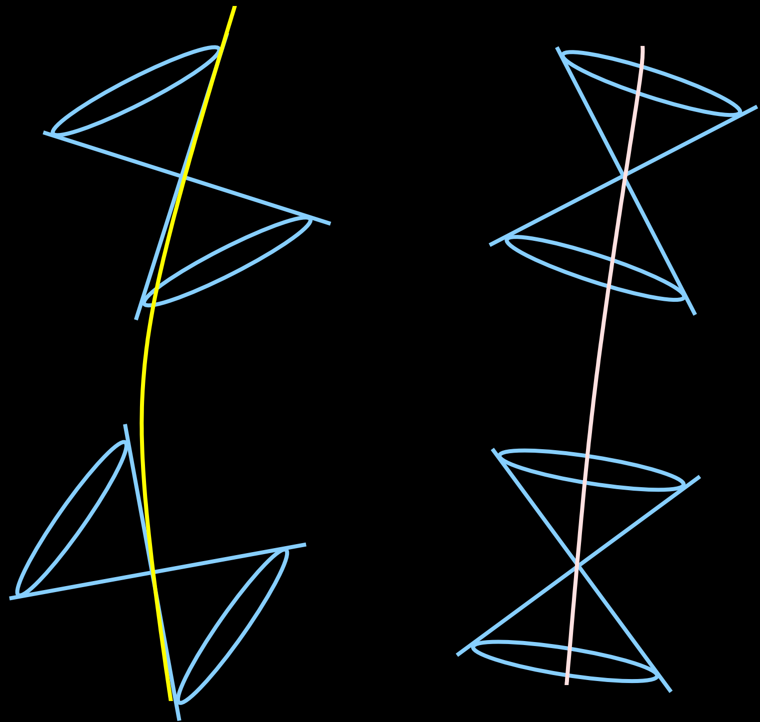

Tilting of local light cones → measure of local spacetime curvature

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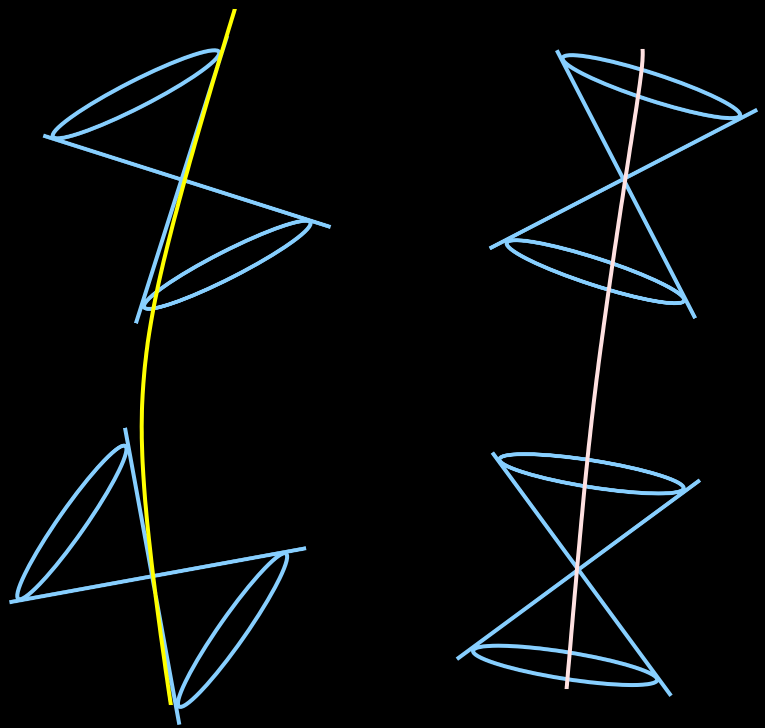

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GRAVITATIONAL FORCE replaced by CURVED SPACETIME GEOMETRY (Gauss, Riemann)

What causes spacetime to curve ?

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Einstein's equation

$$\begin{aligned} \mathcal{G}_{ab} &= 8\pi G T_{ab} \\ \text{sptm curvature} &= 8\pi G \text{ energy} - \text{mom density} \end{aligned}$$

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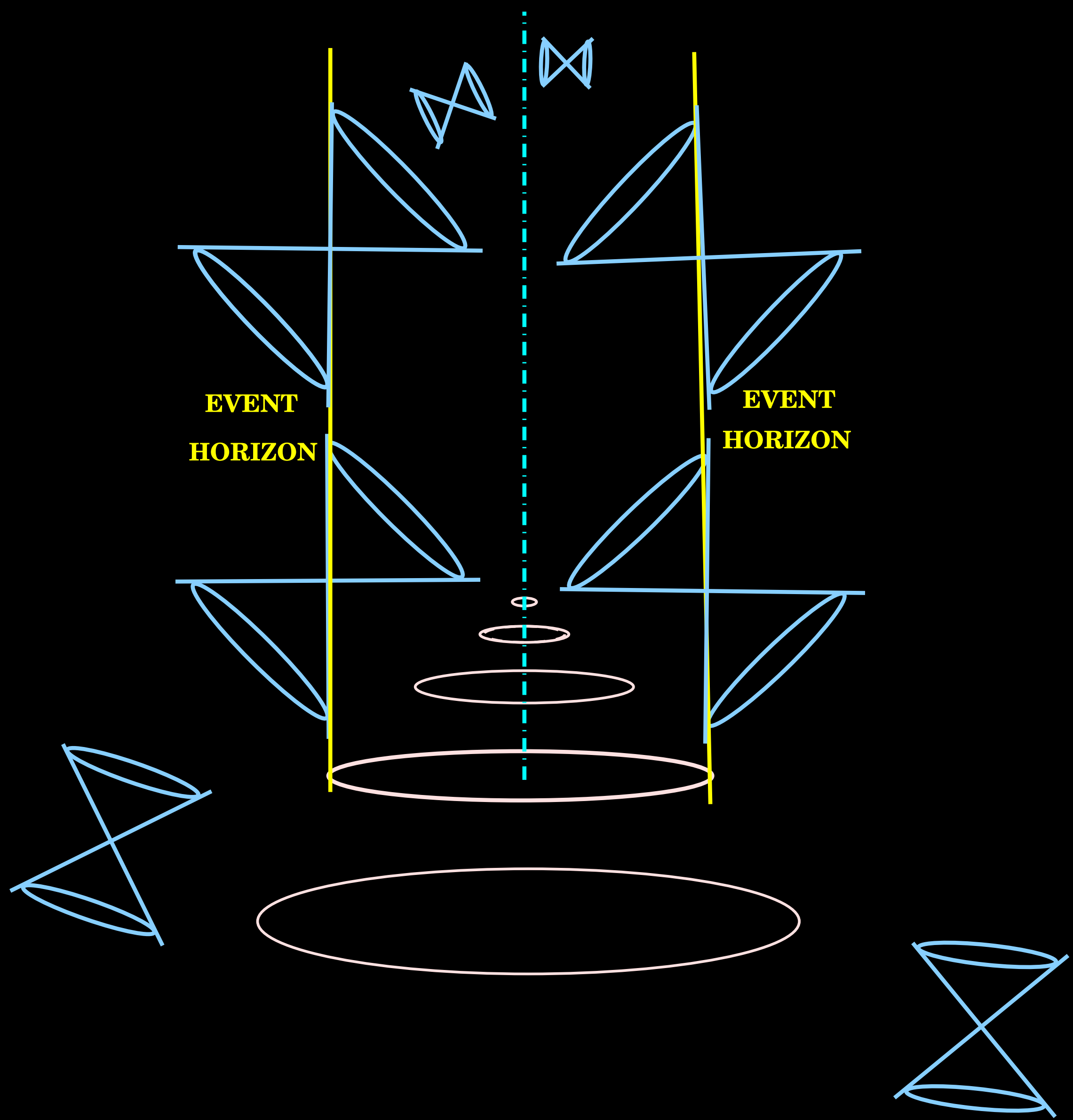
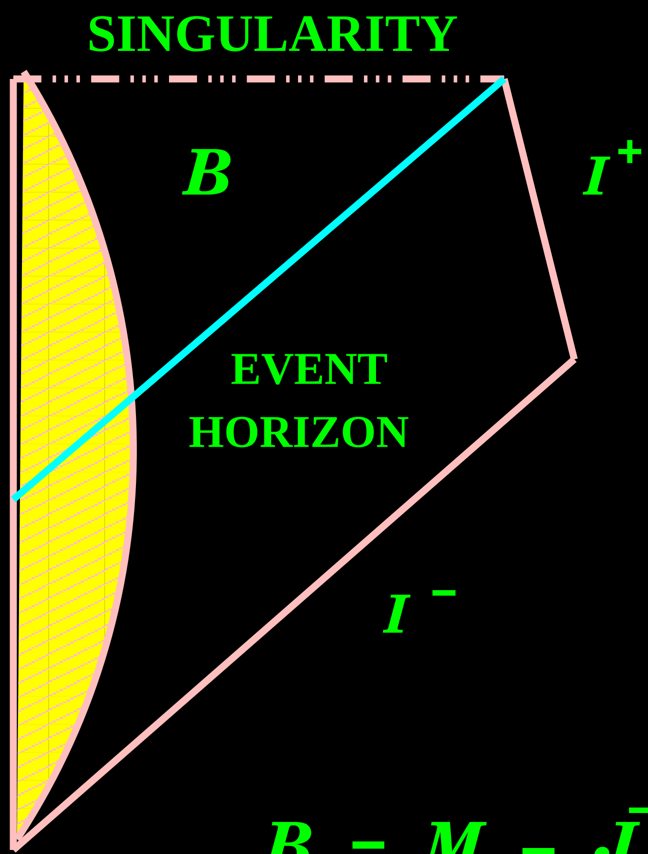
Black hole spacetime Eddington-Finkelstein



Black hole spacetime : another view



$$B = M - \bar{J}(I^{+})$$

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$$\begin{aligned} \delta \mathcal{A}_{hor} &\geq 0 \\ \kappa_{hor} &= const \\ \delta M &= \kappa_{hor}\, \delta \mathcal{A}_{hor} + \cdots \end{aligned}$$

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$\Rightarrow$ **no analogue of** $\mathrm{E}^2 + \mathrm{B}^2$ **in vac GR! Excitations 'polymeric'**

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As $|h| \nearrow$, $bkreactn$ $\nearrow$, approx. invalid

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$$\hat{H}_v |\psi_v\rangle = 0$$

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$$\begin{aligned} Z &= Tr_v \, Tr_b \, \exp \; -\beta \left[\hat{H}_v + \hat{H}_b \right] \\ &= Tr_b \, \exp \; -\beta \hat{H}_b \equiv Z_b \end{aligned}$$

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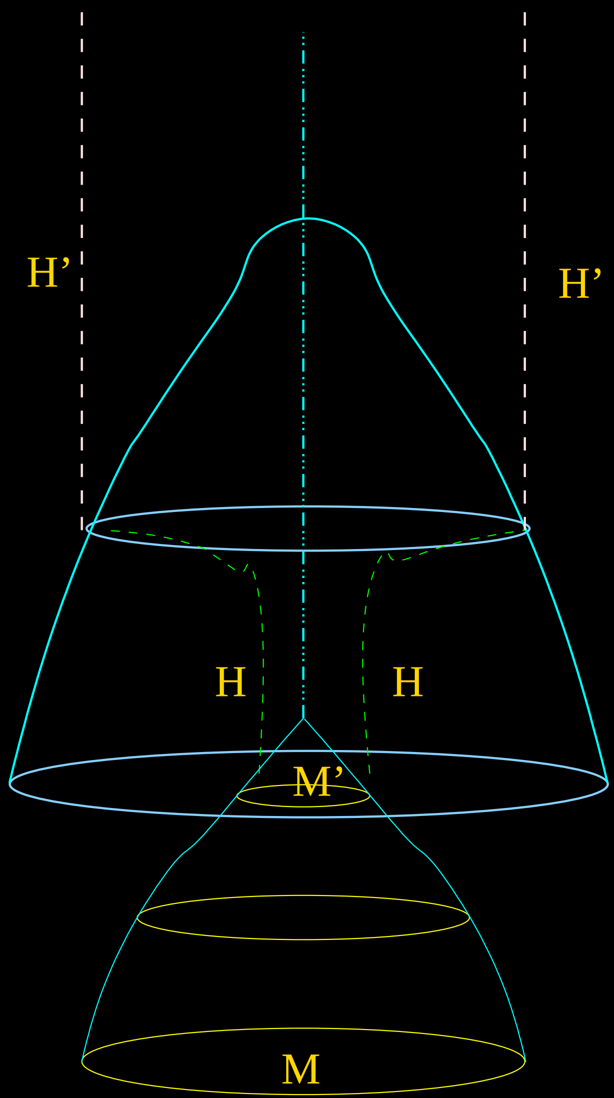
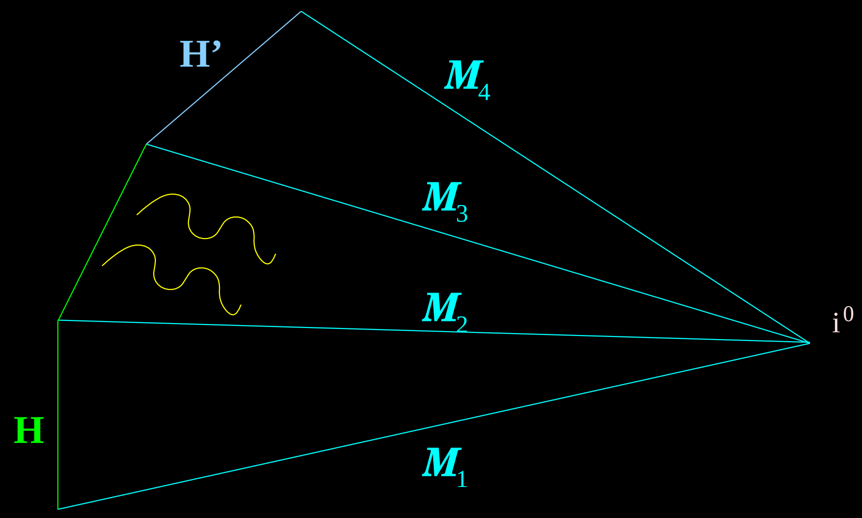
Work with Isolated Horizons (IH) as local, non-stationary generalization of EHs (Ashtekar et. al. 1997-2001)



H’
H’
H
H
M’
M



H’
M_4
M_3
M_2
i^0
H
M_1

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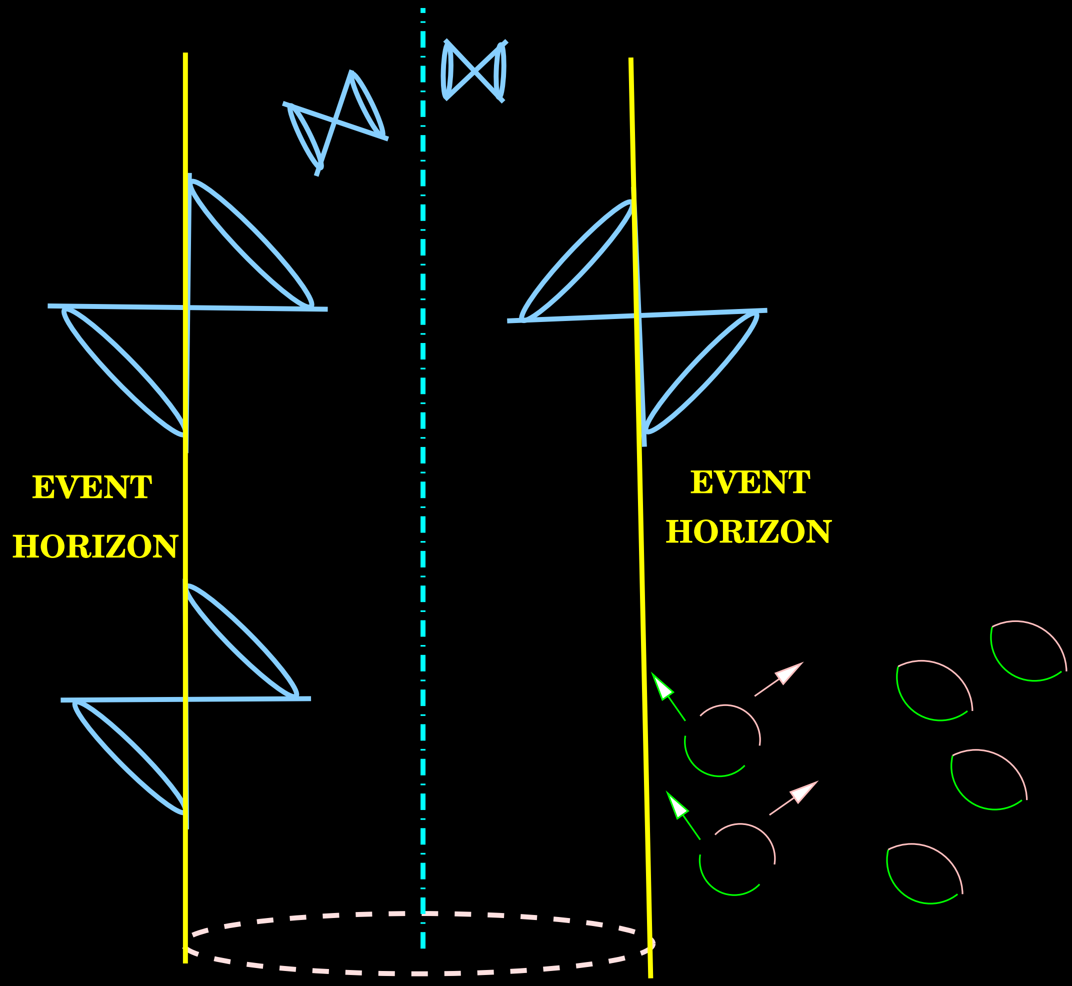
Black hole radiance



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Generalizable to more general black holes with charge and angular momentum, within Grand canonical ensemble Chatterjee, PM 2005; PM in prog

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Quantize CS + sources $\to S_{IH} \equiv \log \dim \mathcal{H}_{CS+sources}$

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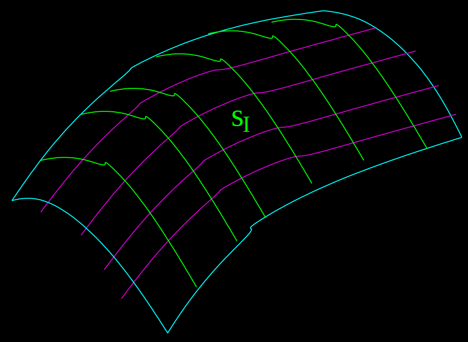
Holonomies completely specified by spin j_l associated with link l

Spin network : Quantum Space

Area operator (also volume, length) have bded, discrete spectrum



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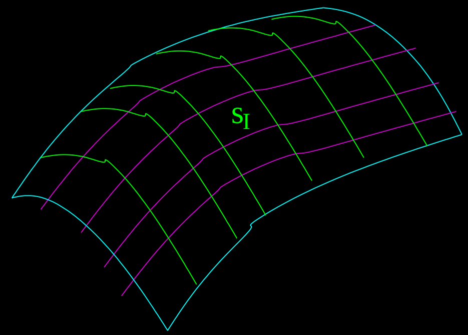

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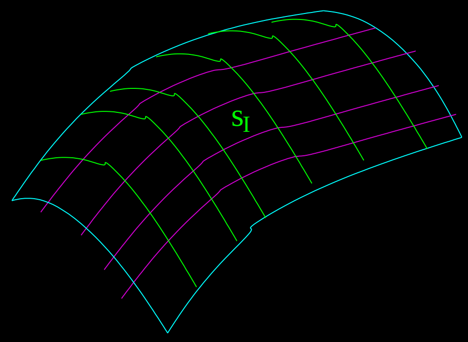

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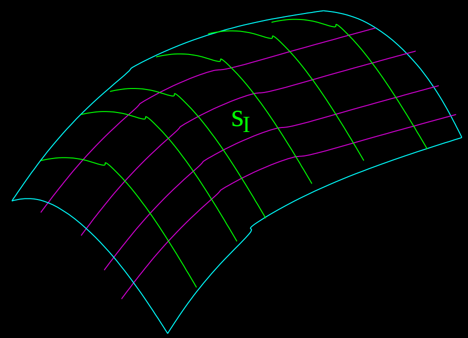

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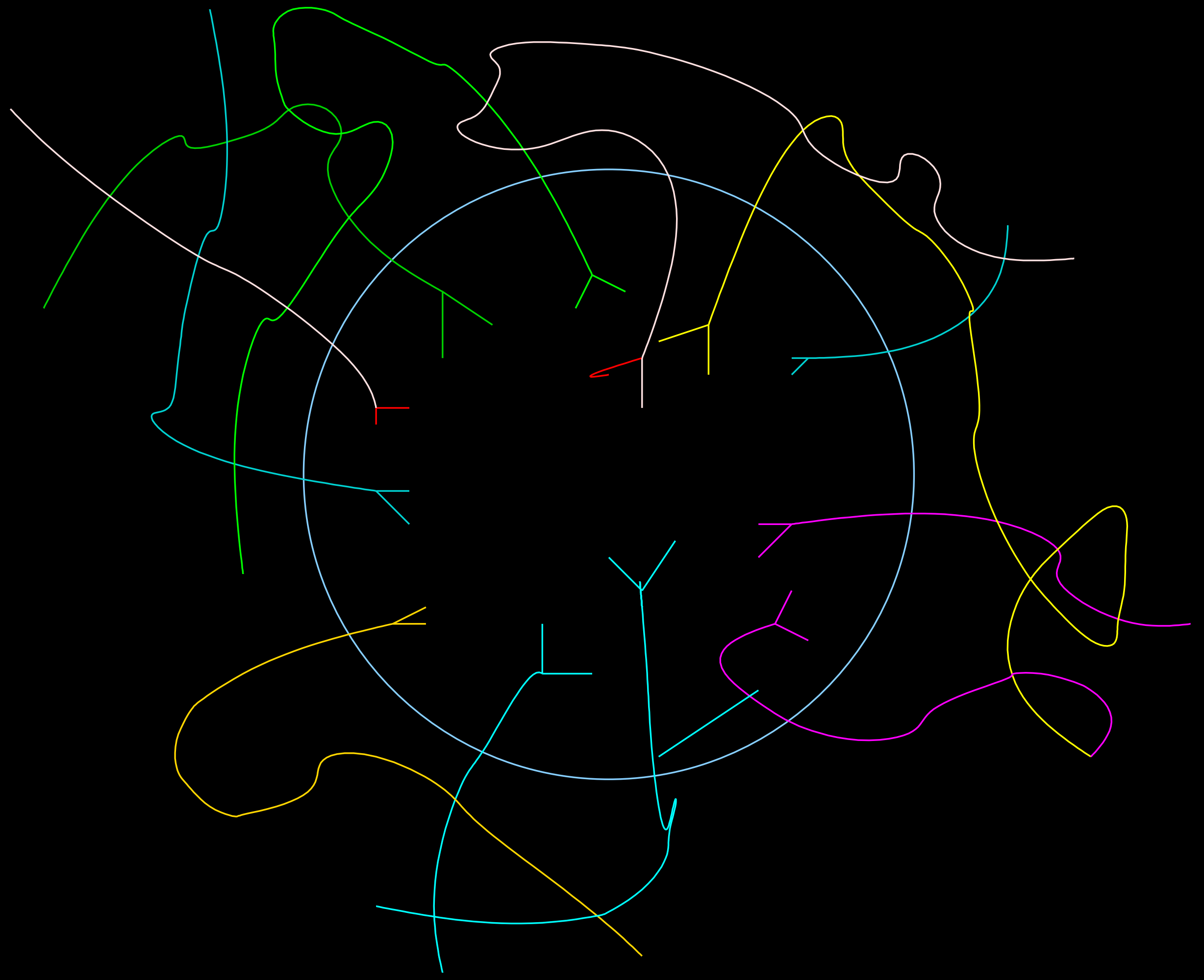
Equispaced $\forall j_p = 1/2$

‘Quantum’ Isolated Horizon → effective description (Ashtekar, Baez, Corichi, Krasnov 1997)



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$\Rightarrow$ (Kaul, PM 1998)

$$\begin{aligned}\dim\ \mathcal{H}_{CS+(j_1,...,j_n)} &= \prod_{p=1}^{n} \sum_{m_p=-j_p}^{j_p} [\delta_{m_1+\cdots+m_n,0} \\ &- \frac{1}{2}\delta_{m_1+\cdots+m_n,-1} \\ &- \frac{1}{2}\delta_{m_1+\cdots+m_n,1}]\end{aligned}$$

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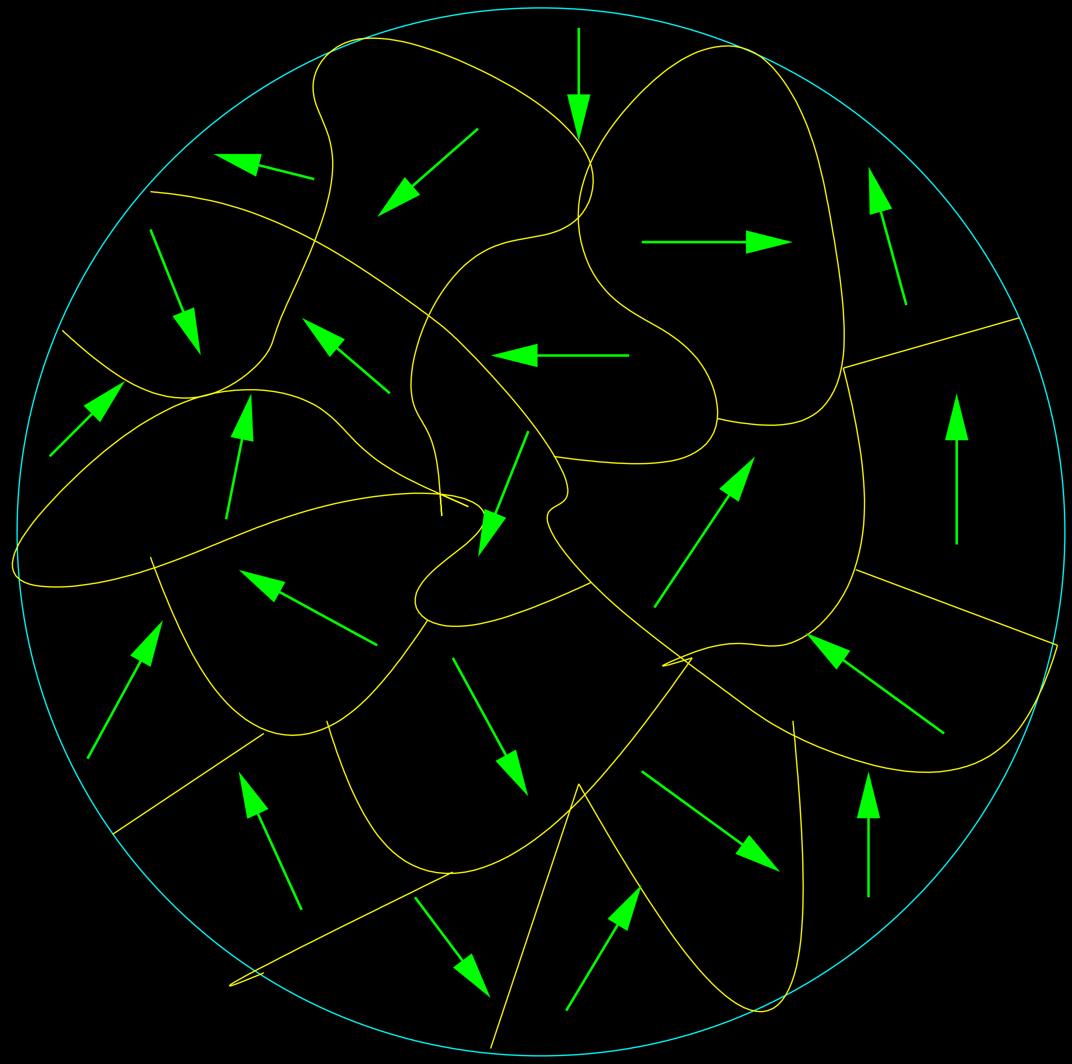
Infinite series of corrections to semicl BHAL : characteristic signature of LQG

IT from BIT



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