4d Schwarzschild

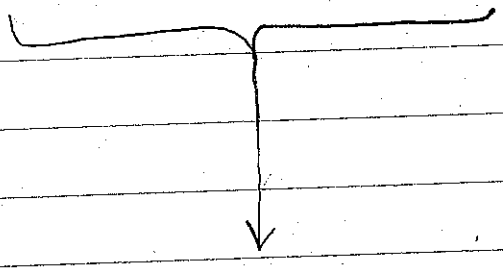
$$\boxed{ds^2 = -f dt^2 + f^{-1} dr^2 + r^2 d\Omega_2^2}$$

$$f = 1 - \frac{2GM}{r}$$

2d Black Hole

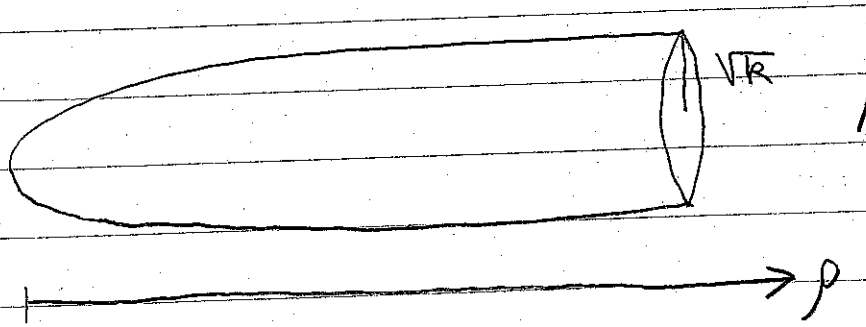
$$ds^2 = -f dt^2 + \frac{k\ell_s^2}{4r^2}\frac{dr^2}{f} + k\ell_s^2 d\Omega_3^2 + ds_{T^5}^2$$

$$e^{-2\Phi} = \frac{r}{\sqrt{2}k\ell_s}$$

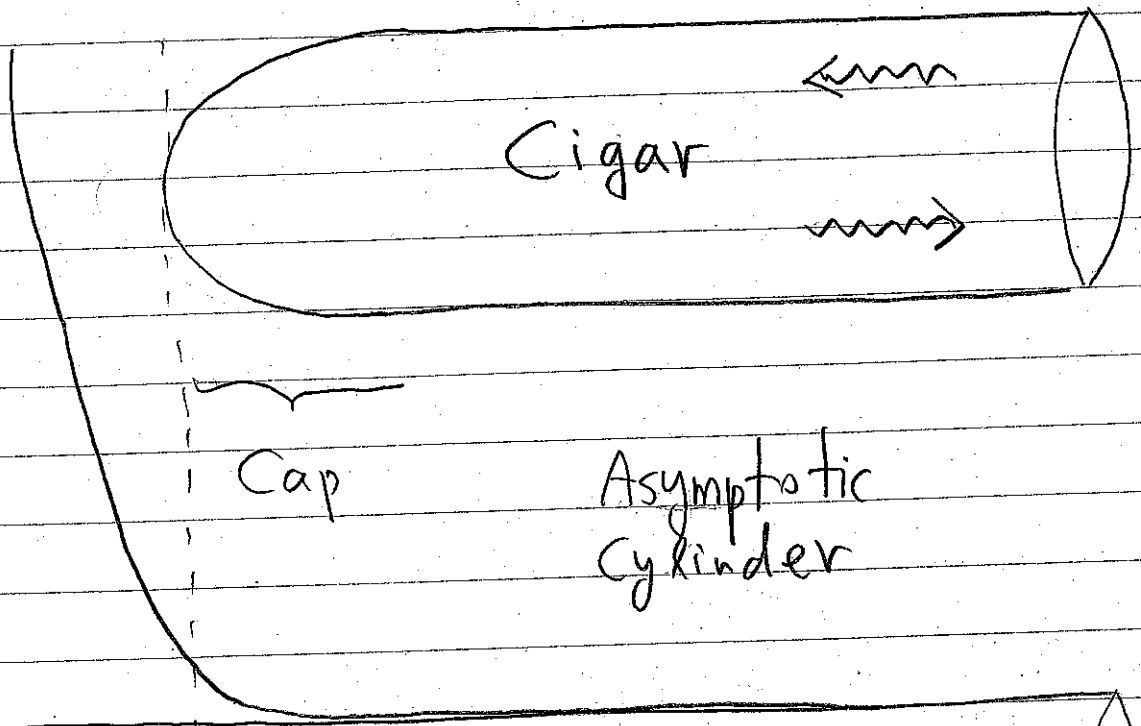


$$\boxed{ds^2 = 2k\tanh^2\left(\frac{\rho}{\sqrt{2k}}\right)d\theta^2 + d\rho^2}$$

$$e^{2\Phi} = \frac{g_{tip}^2}{\cosh^2\left(\frac{\rho}{\sqrt{2k}}\right)}$$

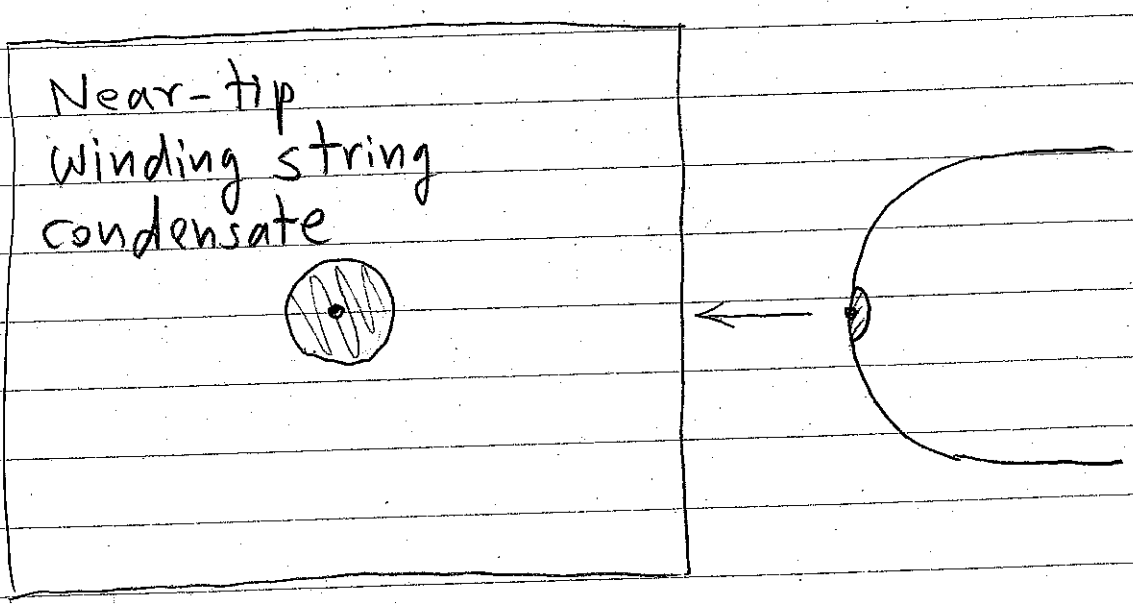


$$\alpha' = \ell_s^2 = 2$$



Sine-Liouville

$$\frac{1}{2}\left((\partial\theta)^2+(\partial\phi)^2+Q\hat{R}\phi\right)+\lambda\left(e^{-\frac{1}{Q}(\phi+i\theta)}+c.c.\right) \qquad \phi \xrightarrow{\phi\to\infty} \rho \qquad Q=\sqrt{\frac{2}{k}}$$



$$(L_0+\bar{L}_0)|\psi\rangle=(h+\bar{h})|\psi\rangle$$

$$L_0=-\frac{1}{k}(\Delta-m^2) \qquad \bar{L}_0=-\frac{1}{k}(\Delta-\bar{m}^2)$$

$$\Delta=\frac{k}{2}\partial_\rho^2+\sqrt{\frac{k}{2}}\coth\left(\frac{\rho}{\sqrt{k/2}}\right)\partial_\rho-\frac{1}{\sinh^2\left(\frac{\rho}{\sqrt{k/2}}\right)}\left(m^2+\bar{m}^2-2\cosh\left(\frac{\rho}{\sqrt{k/2}}\right)m\bar{m}\right)$$

$$(m,\bar{m})=\frac{1}{2}(kw+p,\ -kw-p)$$

$\downarrow$ large k

2d SHO w/ $E=h+\bar{h}-1$

$L=h-\bar{h}$

$$(h,\bar{h})=\left((n_1+\tfrac{1}{2})|w|,(n_2+\tfrac{1}{2})|w|\right)$$

Alternatively:

$$S_{eff} = \frac{1}{4\pi}\int_0^{2\pi} d\theta \int_0^{\infty} dp \sqrt{\frac{k}{2}} \sinh\left(\sqrt{\frac{2}{k}}\rho\right)\left((\partial_\theta T)^2 + (\partial_\rho T)^2 + m^2(\rho)T^2\right)$$

$$m^2(\rho) = -1 + \frac{k}{2}w^2 \tanh^2\left(\frac{\rho}{\sqrt{2k}}\right)$$

0-mode solution: $w=1$

$$T(\rho) = \left(\frac{e^{\Phi}}{g_{tip}}\right)^k = \frac{1}{\cosh^k\left(\frac{\rho}{\sqrt{2k}}\right)}$$

↓ large k

$$e^{-\rho^2/4}$$

Localized a stringy distance from the (Euclidean) horizon

Supported by:

$\langle V \cdots V \rangle$ $\langle VV \rangle = R = e^{i\delta}$

Correlators, e.g. 2Pf → phase shift:

$$e^{i\delta} \simeq \frac{\Gamma\left(\frac{i p_{radial}}{\sqrt{k}}\right)}{\Gamma\left(-\frac{i p_{radial}}{\sqrt{k}}\right)} R_{GR}(p_r, l)$$

$p_r \gg \sqrt{k}$

$\delta_{GR} \to 0$

$$\boxed{\delta_{\substack{\text{winding} \\ \text{string}}} \simeq \frac{1}{\sqrt{k}} p_r \log p_r}$$

* Due to integration over 0-mode of Sine-Liouville field ϕ_0 → interpret in terms of Potential Scattering

* Comes from regime behind the tip that does not exist in the cigar geometry; the 2 regimes are connected at a distance of order l_s, where

$$\frac{1}{2} Q \phi_0 = \log \cosh\left(\frac{\rho}{\sqrt{2k}}\right) \to T \sim e^{-\phi_0/Q} \sim \frac{1}{\cosh^k\left(\frac{\rho}{\sqrt{2k}}\right)}$$

Partition function (∞) →
Helicity Super Trace
Elliptic Genus

$$Z \simeq \mathrm{Tr}(-)^{F+\bar{F}} q^{H} \bar{q}^{\bar{H}} z^{Q} \bar{z}^{\bar{Q}} \cdots$$

$$q = e^{2\pi i \tau} \qquad z = e^{2\pi i \alpha}$$

e.g. Elliptic Genus ($\bar{\alpha}=0$):

$$Z(\alpha,\tau) = \frac{i\theta_{11}}{\eta^3}\left[\sum_{\gamma=0}^{k-1}\sum_{m\in\mathbb{Z}} \frac{q^{km^2-m\gamma} z^{2m-\frac{\gamma}{k}}}{1-zq^{km-\gamma}}\right.$$

(Winding strings)

$$\left. + \sum_{P,W}' \int_{-\infty+i\varepsilon}^{\infty-i\varepsilon} ds\, \Delta\rho(s)\, q^{\frac{s^2}{k}+\frac{(kw+p)^2}{4k}} \bar{q}^{\frac{s^2}{k}+\frac{(kw-p)^2}{4k}} z^{\frac{kw+p}{k}}\right]$$

(GR)

$$\Delta\rho = \rho_{bosons} - \rho_{fermions} = \frac{1}{2\pi i}\frac{d}{ds}\log\frac{R_b}{R_f}$$

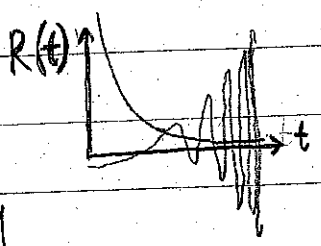
↓ large k

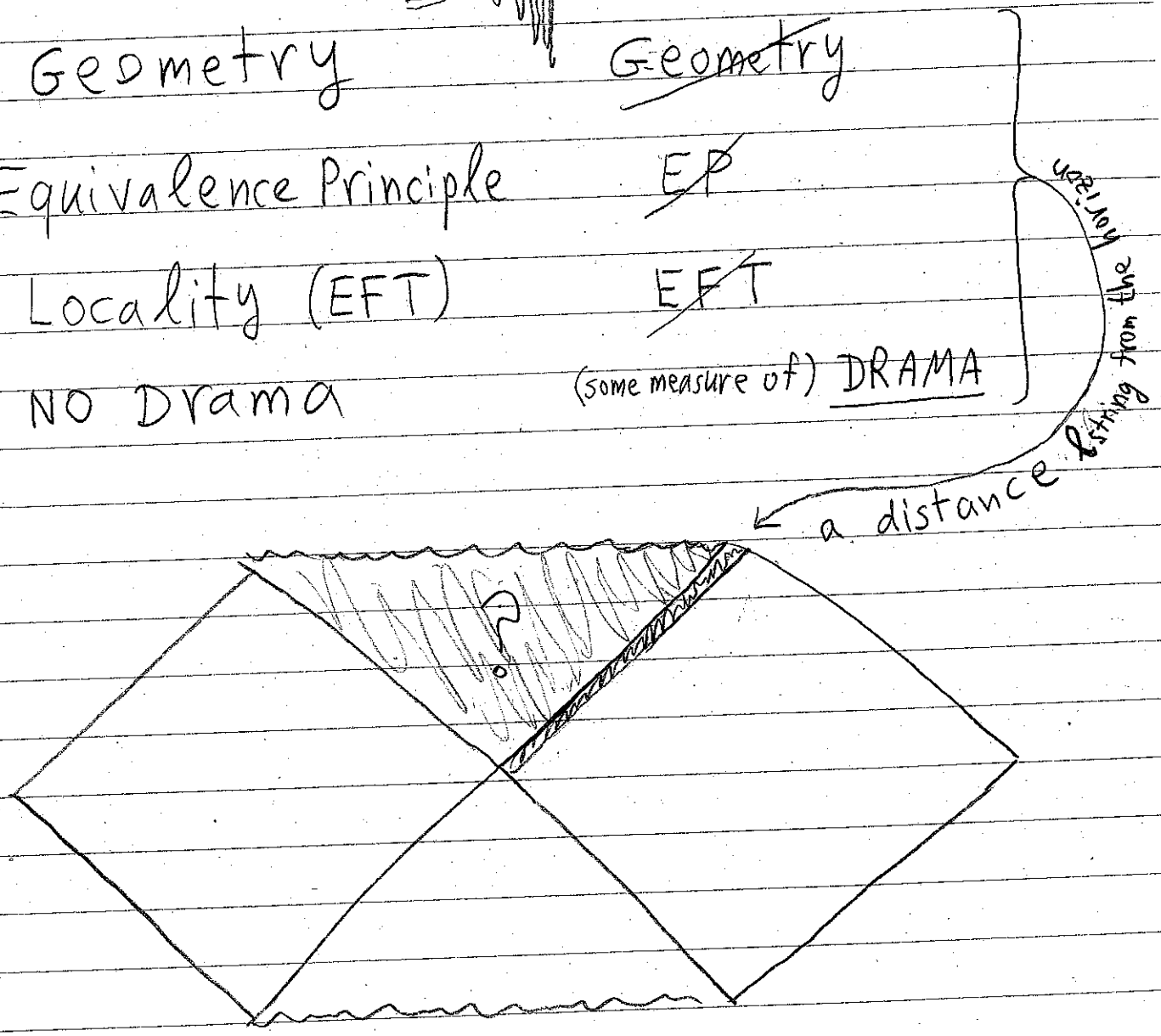
$$\frac{i\theta_1}{\eta^3}\left[\frac{\partial_\alpha \log\theta_1}{2\pi} + \frac{i}{2}\frac{\alpha}{\tau_2}\right] + O\left(\frac{1}{k}\right)$$

Winding condensate and its excitations

Continuum

GR	Stringy horizons
Momentum	Winding
Continuum	Discrete
IR	UV
Geometry	~~Geometry~~
Equivalence Principle	~~EP~~
Locality (EFT)	~~EFT~~
NO Drama	(some measure of) DRAMA





BH Complementarity, Fuzz, Fiery drama, ? / stringy drama

UV/IR mixing / non-locality of (DS)LST