

Title: The Supergravity Duals of D3/D7 Quark Gluon Plasmas

Date: Sep 29, 2009 11:00 AM

URL: <http://pirsa.org/09090025>

Abstract: We present a string dual to finite temperature $N=4$ SYM coupled to N_f massless flavors with abelian symmetry. The solution includes the backreaction of the flavor up to second order in the ratio N_f/N_c times the 't Hooft coupling at the temperature of the dual QGP. The thermodynamics show a departure from conformality as a second order effect, and the energy loss of a quark through the plasma is enhanced by new degrees of freedom.

HOLOGRAPHIC D3D7 QGP WITH FLAVOR

(Biggs), A. Caldeira, J. K. K., A. P. P., A. P. P., 51

Q1Y1:0909.2865

Outline:

- Substituting the flavor
- Ansatz
- Solution
- Regime of validity
- Thermodynamics
- Cross line of particles through the plasma

HOLOGRAPHIC D3/D7 QGP WITH FLAVOR

(Boggs), A. Caldeira, J. K. K., A. P. P., A. R. R., J. J.

QY: 0909.2865

OUTLINE:

- Subverting the Harbours
- Assets
- Solutions
- Regime of stability
- Thermodynamics
- Cross line of particles through the plasma

HOLOGRAPHIC D3/D7 QGP WITH FLAVOR

(Boggs), A. Caldeira, J. K. K., A. P. P., A. R. R., J. J.

QY: 0909.2865

Outline:

- Substituting the flavor
- Ansatz
- Solution
- Regime of validity
- Thermodynamics
- Cross line of particles through the plasma

HOLOGRAPHIC DSD7 QGP WITH FLAVOR

Foraggi, A. Colture, J. Ag., A. Pesticidi, A. Rarità. 31

Q1Y4:0709.2H65

Our Line:

- Solubility of fluorides
- Acids
- Solutions
- Region of stability
- Thermal properties
- Cross line of protons through the plasma

HOLOGRAPHIC BBD7 QGP WITH FLAVOR

Coraggio, A. Colino, J. Ace, A. Poleska, A. Rando, J. I.

QY: 0709.2865

Our client:

- Solubility of fluorides
- Acids
- Solutions
- Degree of acidity
- Thermal properties
- Cross link of proteins through the groups

XENOGRAPHIC DSD7 QGP WITH FLAVOR

(Daggy, A. Côté, J. A., A. P. A. R. A. R. A. J.)

Revis: 0909.2865

OUTLINE:

- Substituting the flavorless
- Ansatz
- Solution
- Regime of validity
- Thermodynamics
- Crossed line of particles through the plasma

HOLOGRAPHIC D3/D7 QGP WITH FLAVOR

(Duggal, A. Gholami, J. Aro, A. Parnachev, A. Ruccia, J.)

ReViz: 0909.2865

OUTLINE:

- Submerging the flavor lines
- Ansatz
- Solution
- Regime of validity
- Thermodynamics
- Critical line of phase transitions through the plasma



HOLOGRAPHIC D3/D7 QGP WITH FLAVOR

(Dagotto, A. Côté, J. Aro, A. Parnachev, A. Rondo, J.)

arXiv:0909.2865

OUTLINE:

- Submerging the flavor lines
- Ansatz
- Solution
- Regime of validity
- Thermodynamics
- Crossover of quarks through the plasma



HOLOGRAPHIC D3/D7 QGP WITH FLAVOR

(Dagotto, A. Côté, J. Aro, A. Pineda, A. Rondo, J.)

arXiv:0909.2865

OUTLINE:

- Spinning the flavor lines
- Ansatz
- Solution
- Regime of validity
- Thermodynamics
- Crossing of quarks through the plasma



HOLOGRAPHIC D3/D7 QGP WITH FLAVOR

[Bigazzi, A. Ciotone, J. Das, A. Paredes, A. Ranello, J. T.]

arXiv:0909.2865

OUTLINE:

- Smearing the flavor branes
- Ansatz
- Solution
- Regime of validity
- Thermodynamics
- Energy loss of partons through the plasma

Karck K213

$$N_c \rightarrow \infty$$

$$\sum_{i=1}^2 N_c \rightarrow \infty$$

Korck Kolz

$$N_c \rightarrow \infty$$

$$\sum_{i=1}^2 N_c \rightarrow \text{fixed}$$

Korck Kitz

$$N_c \rightarrow \infty$$

$$\text{Sim}^? N_c \rightarrow \text{fixed}$$

Karck Kitz

$$N_c \rightarrow \infty$$

$$\text{Sim } N_c \rightarrow \text{fixed}$$

$$N_f \rightarrow \text{fixed} / \text{Sim } N_f \rightarrow \infty$$

Karck Kitz

$$N_c \rightarrow \infty$$

$$\text{Sym } N_c \rightarrow \text{fixed}$$

$$N_f \rightarrow \text{fixed} / \text{Sym } U_f \rightarrow$$

KarrK K₂T₂ (T=0)

$$N_c \rightarrow \infty$$

$$\text{Sym } N_c \rightarrow \text{fixed}$$

$$N_f \rightarrow \text{fixed} / \text{Sym } U_f \rightarrow 0$$

Karrk Ketz (T:0)

$$N_c \rightarrow \infty$$

$$\sum N_c \rightarrow \text{fixed}$$

$$N_f \rightarrow \text{fixed} / \sum N_f \rightarrow 0$$

$$S = S_{\text{old}} + o\left(\frac{N_c}{N_c}\right)$$

Karck Ketz (T:0)

$$N_c \rightarrow \infty$$

$$\sum N_c \rightarrow \text{fixed}$$

$$N_f \rightarrow \text{fixed} / \sum V_f \rightarrow 0$$

$$S_{N_c} \rightarrow O\left(\frac{N_c}{N_c}\right)$$

Karck Katz (T.O)

Veneziano

$$N_c \rightarrow \infty$$

$$S_{YM} N_c \rightarrow \text{fixed}$$

$$N \rightarrow \text{fixed} / g_{YM}^2 \rightarrow 0$$

$$1 + O\left(\frac{N_c}{N_c}\right)$$

Karr-Katz (T=0)

$$N_c \rightarrow \infty$$

$$\sum N_c \rightarrow \text{fixed}$$

$$\sum N_f \rightarrow \text{fixed}$$

$$S \rightarrow 0 \left(\frac{N_f}{N_c} \right)$$

Veneziano

$$N_c \rightarrow \infty$$

$$\frac{N_f}{N_c} \rightarrow \text{fixed}$$

$$\sum N_f > 1$$

Karck Katz (T=0)

$$N_c \rightarrow \infty$$

$$\sum N_c \rightarrow \text{fixed}$$

$$N_f \rightarrow \text{fixed}$$

$$S = S_{\text{dual}} + O\left(\frac{N_f}{N_c}\right)$$

Veneziano

$$N_c \rightarrow \infty$$

$$\frac{N_f}{N_c} \rightarrow \text{fixed} \quad \sum N_f > 1$$

$$\frac{N_f}{N_c}$$

Karr-Katz (T=0)

$$N_c \rightarrow \infty$$

$$g_{YM}^2 N_c \rightarrow \text{fixed}$$

$$N_f \rightarrow \text{fixed} / g_{YM}^2 N_f \rightarrow 0$$

$$S = S_{\text{class}} + o\left(\frac{N_f}{N_c}\right)$$

Veneziano

$$N_c \rightarrow \infty$$

$$\frac{N_f}{N_c} \rightarrow \text{fixed}$$

$$g_{YM}^2 N_f > 1$$

$$\left(\frac{N_f}{N_c}\right)^2$$

Karck Katz (T=0)

$$N_c \rightarrow \infty$$

$$\sum N_c \rightarrow \text{fixed}$$

$$N_f \rightarrow \text{fixed} / \sum N_f \rightarrow 0$$

$$S = S_{\text{class}} + o\left(\frac{N_f}{N_c}\right)$$

Veneziano

$$N_c \rightarrow \infty$$

$$\frac{N_f}{N_c} \rightarrow \text{fixed}$$

$$\sum N_f > 1$$

$$\left(\frac{N_f}{N_c}\right)^2$$

Karck Katz (T=0)

$$N_c \rightarrow \infty$$

$$g_{\text{YM}}^2 N_c \rightarrow \text{fixed}$$

$$N_f \rightarrow \text{fixed} / g_{\text{YM}}^2 N_f \rightarrow 0$$

$$S = S_{\text{class}} + o\left(\frac{N_f}{N_c}\right)$$

Veneziano

$$N_c \rightarrow \infty$$

$$\frac{N_f}{N_c} \rightarrow \text{fixed}$$

$$g_{\text{YM}}^2 N_f > 1$$

$$\left(\frac{N_f}{N_c}\right)^2$$

Karck Kitz (T=0)

$$N_c \rightarrow \infty$$

$$S_{\text{YM}} N_c \rightarrow \text{fixed}$$

$$N_f \rightarrow \text{fixed} / S_{\text{YM}} N_f \rightarrow 0$$

$$S = S_{\text{YM}} + o\left(\frac{N_f}{N_c}\right)$$

Veneziano

$$N_c \rightarrow \infty$$

$$\frac{N_f}{N_c} \rightarrow \text{fixed}$$

$$S_{\text{YM}} N_f > 1$$

$$\left(\frac{N_f}{N_c}\right)^2$$

A person with short dark hair, wearing a light-colored long-sleeved shirt and dark pants, is seen from behind. They are standing in front of a large black chalkboard, with their right arm raised to write on it. Their left hand is on their hip.
$$S = S_{DB} + \sum_{i=1}^N S_{DB,i}$$

$$S = S_{DB} + \sum_{i=1}^N (S_{DB,i} + S_{N,i})$$

$$S = S_{DB} + \sum_{i=1}^N (S_{DB,i} + S_{N,i})$$

$$S = S_{DB} + \sum_{i=1}^M (S_{DB,i} + S_{N,i})$$

i)

$$S = S_{DB} + \sum_{i=1}^M (S_{DB,i} + S_{N,i})$$

i)

$$S = S_{DB} + \sum_{i=1}^{N_f} (S_{DB,i} + S_{N2})$$

$$i) N_f \leq 12$$

$$S = S_{DB} + \sum_{i=1}^{N_f} (S_{DB,i} + S_{N,i})$$

i) $N_f \leq 12$

ii)

$$S = S_{DB} + \sum_{i=1}^{N_f} (S_{DB,i} + S_{N,i})$$

i) $N_f \leq 12$

ii) $U(N_f)$

$$S = S_{DB} + \sum_{i=1}^{N_f} (S_{DB,i} + S_{N,i})$$

$$i) N_f \leq 12$$

$$ii) U(N_f) \quad g_{YM}^2 N_f$$

$$S = S_{DB} + \sum_i (S_{DBi} + S_{N2})$$

i) $N_f \leq 12$

ii) $U(N_f) \quad g_{YM}^2 N_f$

iii)

$$S = S_{DB} + \sum_i (S_{DB,i} + S_{N,i})$$

i) $N_f \leq 12$

ii) $U(N_f) \quad g_{YM}^2 N_f$

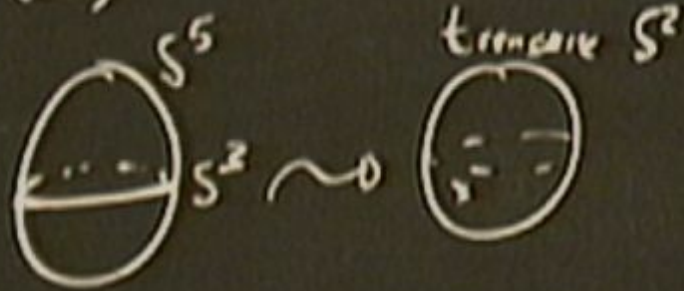
iii) direct deltas $\rightarrow$ eon

$$S = S_{DB} + \sum_i (S_{DB,i} + S_{N,i})$$

i) $N_f \leq 12$

ii) $U(N_f)$ $g_{YM}^2 N_f$

iii) direct deltas $\rightarrow$ eon

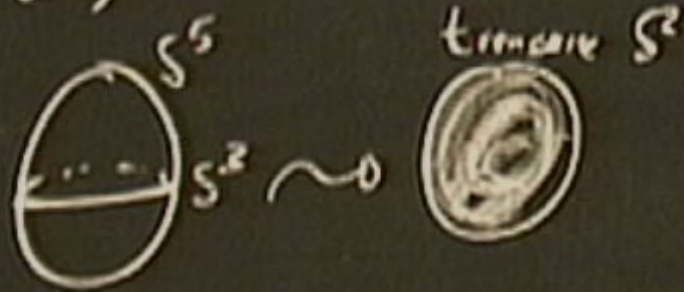


$$S = S_{DB} + \sum_i (S_{DB,i} + S_{N,i})$$

i) $N_f \leq 12$

ii) $U(N_f)$ $g_{YM}^2 N_f$

iii) direct deltas $\rightarrow$ eon

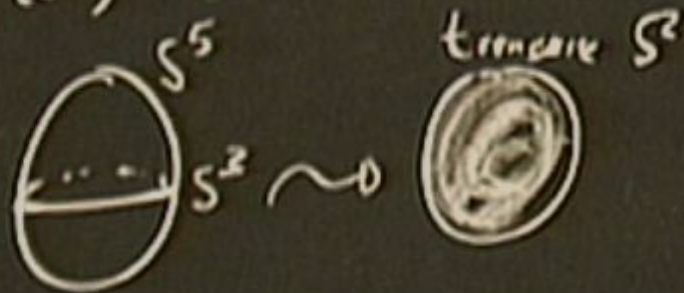


$$S = S_{DB} + \sum_i (S_{DB,i} + S_{N,i})$$

i) $N_f \leq 12$

ii) $U(N_f)$ $g_{YM}^2 N_f$

iii) direct deltas $\rightarrow$ con

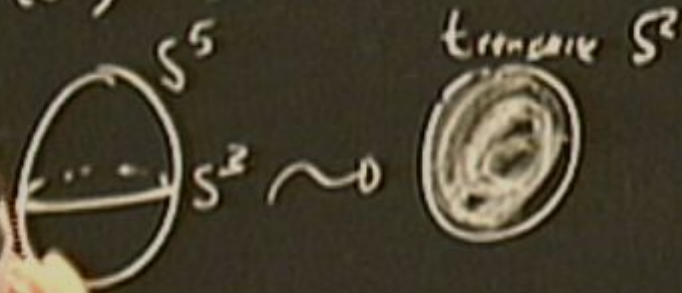


$$S = S_{DB} + \sum_i (S_{DB,i} + S_{N,i})$$

i) $N_f \leq 12$

ii) $U(N_f)$
 $\rightarrow \text{DUCI}_{N_f}^{g_{YM}^2 N_f}$

iii) direct deltas $\rightarrow$ EOM $\checkmark$

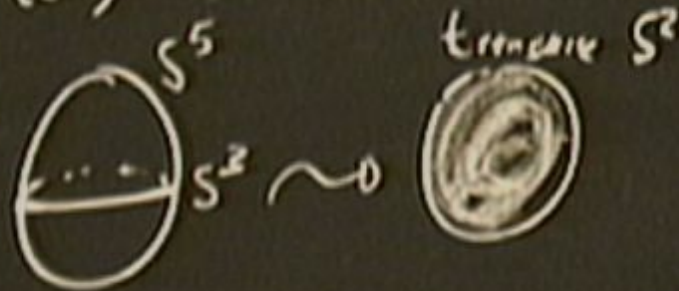


$$S = S_{DB} + \sum_i (S_{DB,i} + S_{N,i})$$

i) $N_f \leq 12$

ii) $U(N_f) \rightarrow \text{DUCIS } N_f \frac{g_{YM}^2 N_f}{R^2}$

iii) direct deltas $\rightarrow$ deon ✓

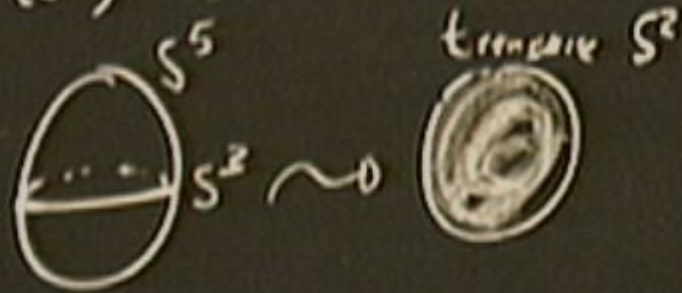


$$S = S_{DB} + \sum_i (S_{DB,i} + S_{N,i})$$

i) $N_f \leq 12$

ii) $U(N_f) \rightarrow \text{DUCI} \rightarrow \frac{g_{YM}^2 N_f}{R^2 \rightarrow \infty}$

iii) direct deltas $\rightarrow$ EOM $\checkmark$

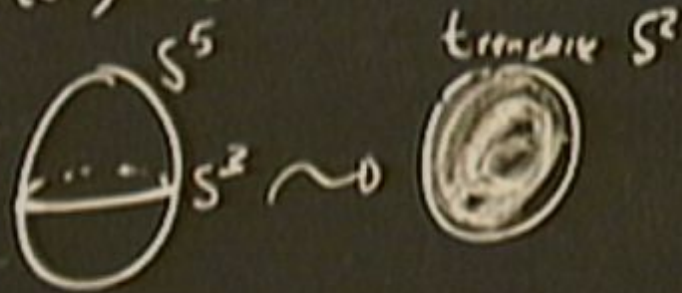


$$S = S_{DB} + \sum_i (S_{DB,i} + S_{N,i})$$

i) $N_f \leq 12$

ii) $U(N_f)$ $\rightarrow$ $DU(N_f)$ $\frac{g_{YM}^2 N_f}{R^2 \rightarrow \infty}$ ✓

iii) direct deltas $\rightarrow$ deon ✓

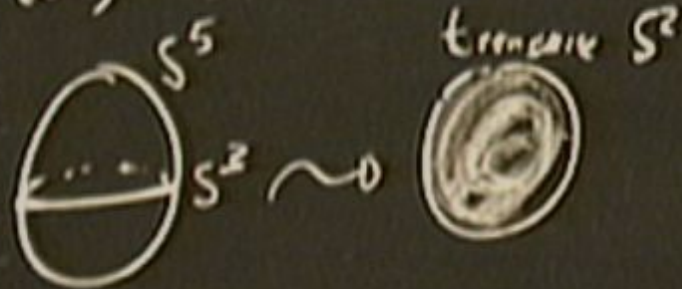


$$S = S_{DB} + \sum_i (S_{DB,i} + S_{N,i})$$

i) $N_f \leq 12 \checkmark$

ii) $U(N_f) \rightarrow \text{DUCIS } N_f \frac{g_{YM}^2 N_f}{R^2 \omega^2} \checkmark$

iii) direct deltas $\rightarrow$ deon $\checkmark$



>1

i) $N_f \leq 12 \checkmark$

ii) $U(1)^{N_f}$ $\frac{g_{YM}^2 N_f}{R^2 \omega_0} \checkmark$

iii) ϵ delts $\rightarrow$ $\epsilon \otimes \pi \checkmark$
tension S^2



$$\left(\frac{N_f}{R^2} \right)$$

$$S = S_{DB} + \sum_i^{N_f} (S_{DB,i} + S_{N,i})$$

i) $N_f \leq 12$ ✓

ii) $U(N_f) \rightarrow \text{DUC}(N_f) \frac{g_{YM}^2 N_f}{R^2 \epsilon_0} \checkmark$

iii) direct delta $\rightarrow \epsilon \otimes \pi \checkmark$



$$S_{WZ} = -T_2 \sum_i^{N_f} \int C_2$$



$$-\frac{T_2 N_f}{W_1(X_2)} \int D(r) \mathcal{E}(X_2) \wedge C_2$$

$$S = S_{DB} + \sum_{i=1}^{N_f} (S_{DB,i} + S_{N,i})$$

i) $N_f \leq 12$ ✓

ii) $U(N_f) \rightarrow DU(N_f) \frac{g_{YM}^2 N_f}{R^2 \epsilon} \checkmark$

iii) ac deltas $\rightarrow$ eon ✓

truncate S^2

$$\left(\frac{N+2}{R^2} \right)$$

$$S_{WZ} = -T_2 \sum_{i=1}^{N_f} \int C_S$$



$$\frac{-T_2 N_f}{W_1(X_2)} \int D(r) \underline{E(X_2)} \wedge C_8$$

$$S = S_{DB} + \sum_i^{N_f} (S_{DB,i} + S_{N,i})$$

i) $N_f \leq 12$ ✓

ii) $U(N_f) \rightarrow \text{DUC}(N_f) \frac{g_{YM}^2 N_f}{R^2 \omega^2}$ ✓

iii) direct deltas $\rightarrow$ EOM ✓

$S^2 \sim \text{truncate } S^2 \left(\frac{N_f + 2}{R^2} \right)$

$$S_{WZ} = -T_2 \sum_i^{N_f} \int C_S$$



$$\frac{-T_2 N_f}{W_1(X_2)} \int D(r) \underline{E(X_2)} \wedge (8$$

$$S = S_{DB} + \sum_i^{N_f} (S_{DBi} + S_{N2})$$

i) $N_f \leq 12$ ✓

ii) $U(N_f) \rightarrow \text{DUC}(N_f) \frac{g_{YM}^2 N_f}{R^2 \log}$ ✓

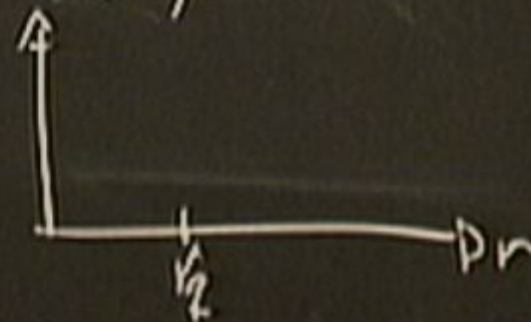
iii) direct del. for ✓

S^5 $S^2 \sim \frac{N_f + 2}{R^2}$

$$S_{W2} = -T_2 \sum_i^{N_f} \int C_2$$



$$\frac{-T_2(N_f)}{W_1(R_2)} \int \underline{P(r)} \underline{E(R_2)} \wedge C_2$$



$$S = S_{DB} + \sum_i^{N_f} (S_{DB1} + S_{N2})$$

i) $N_f \leq 12$ ✓

ii) $U(N_f) \rightarrow DU(N_f) \frac{g_{YM}^2 N_f}{r^2 \rightarrow \infty}$ ✓

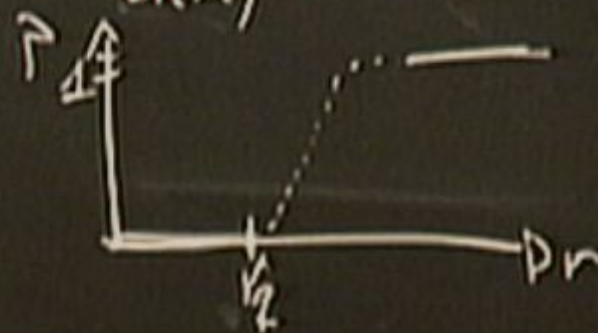
iii) direct $\rightarrow$ DEON ✓



$$S_{WZ} = -T_2 \sum_i^{N_f} \int C_2$$



$$-\frac{T_2(N_f)}{W_1(X_2)} \int \underline{P(r)} \underline{E(X_2)} \wedge C_2$$

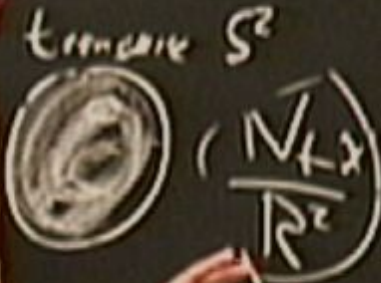


$$S = S_{DB} + \sum_i^{N_f} (S_{DB,i} + S_{N,i})$$

i) $N_f \leq 12$ ✓

ii) $U(N_f)$ $\frac{g_{YM}^2 N_f}{R^2 \omega}$ ✓

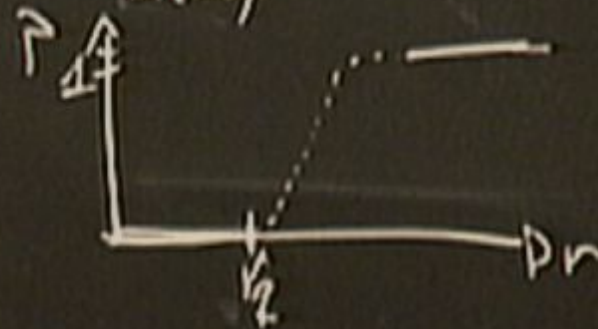
iii) direct to $SO(N_f)$ ✓



$$S_{WZ} = -T_f \sum_i^{N_f} \int C_i$$



$$-T_f(N_f) \int \frac{P(r)}{W(r)} \frac{E(r)}{W(r)} \wedge C$$



$$S = S_{IB} + \sum_i (S_{DBi} + S_{Ni})$$

i) $N_f \leq 12$ ✓

ii) $U(N_f) \rightarrow D(N_f) \frac{g_{YM}^2 N_f}{R^2 \rightarrow \infty}$ ✓

iii) dir $t_2 \rightarrow \text{con}$ ✓



$$S_{wp} = -T_p \sum_i^{N_i} \int C_p$$



$$-\frac{T_2(N_2)}{U_1(X_2)} \int \underline{P(r)} \underline{E(X_2)} \wedge (8$$



$$S = S_{DB} + \sum_i^{N_f} (S_{DB,i} + S_{A,i})$$

i) $N_f \leq 12$ ✓

ii) $U(N_f) \rightarrow \text{DUC}(N_f) \frac{g_{YM}^2 N_f}{R^2 \omega^2}$ ✓

iii) direct d → $\epsilon \otimes \pi$ ✓



$$S_{WZ} = -T_2 \sum_i^{N_f} \int C_2$$



$$\frac{-T_2(N_f)}{W_1(X_2)} \int \underline{P(r)} \underline{E(X_2)} \wedge C_2$$

$$-T_2 \int Q \wedge C_2$$



$$f_i(p^i, y^M)$$

$$f_i(p^i, x^i) = 0$$

$$f_i(p^i, x^i) = 0$$

$$f_i(p^i, x^M) = 0$$

$$f_i(p^i, x^M) = 0$$

$$Q =$$

$$f_1(p^i, x^{\mu}) = 0$$

$$f_2(p^i, x^{\mu}) = 0$$

$$Q = \int \delta(f_1) \delta(f_2) d\mathbf{f}_1 \wedge d\mathbf{f}_2$$

$$f_1(p^i, x^M) = 0$$

$$f_2(p^i, x^M) = 0$$

$$Q = \int \delta(f_1) \delta(f_2) df_1 \wedge df_2$$

$$f_1(p^i, x^M) = 0$$

$$f_2(p^i, x^M) = 0$$

$$Q = \rho(\varphi) \delta(t_1) \delta(t_2) dt_1 \wedge dt_2$$

$$f_1(p^i, x^M) = 0$$

$$f_2(p^i, x^M) = 0$$

$$Q = \int p(q) \delta(t_1) \delta(t_2) dt_1 \wedge dt_2 dP_1$$

$$= 0$$

$$f_1(p^i, x^\mu) = 0$$

$$f_2(p^i, x^\mu) = 0$$

$$Q = \int p(q_1) \delta(t_1) \delta(t_2) dt_1 \wedge dt_2 dp_1$$

$$\tau = 0$$

$$\chi = 0$$

$$f_1(p^i, x^M) = 0$$

$$f_2(p^i, x^M) = 0$$

$$Q = \int p(q_1) \delta(t_1) \delta(t_2) dt_1 \wedge dt_2 dp_1$$

$$f_1(p^i, x^M) = 0$$

$$f_2(p^i, x^M) = 0$$

$$Q = \int p(q_1) \delta(t_1) \delta(t_2) dt_1 \wedge dt_2 dp_1$$

$$S_{WZ} = - \int Q \wedge \epsilon$$

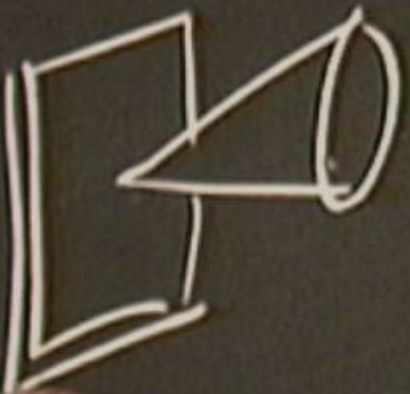
$$t_2(p', x') = 0$$

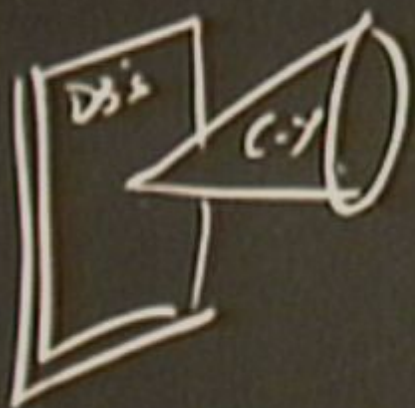
$$Q = \int p(p) \delta(t_1) \delta(t_2) dt_1 \wedge dt_2 dp$$

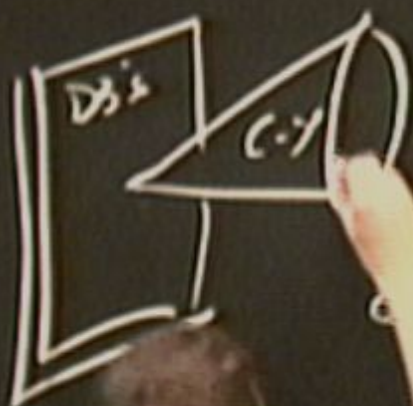
$$S_{\text{WZ}} = - \int Q \wedge \ell_8$$



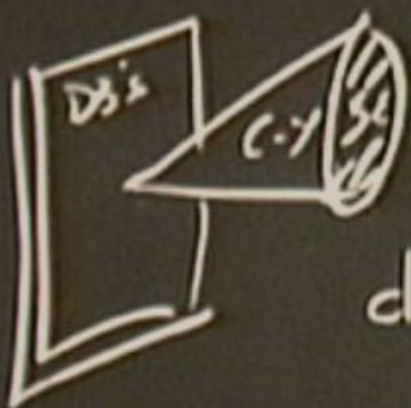
$$d\Gamma_0 = - g_5 Q$$



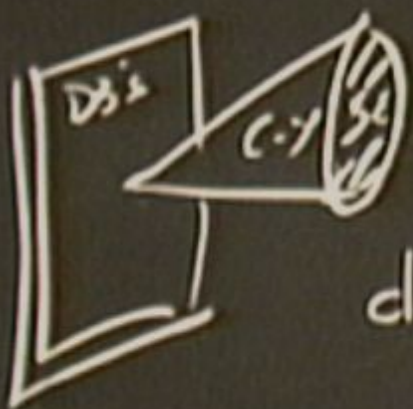




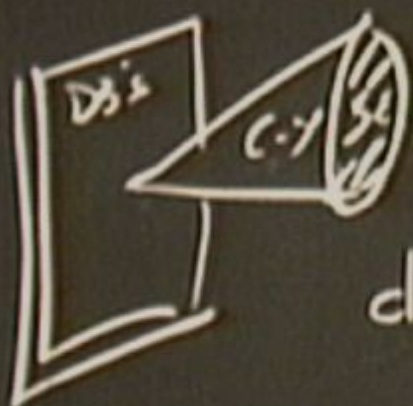
$$dS_{cy}^2 = dr^2 + dS_{sc}^2$$



$$dS_{\mu\nu}^2 = dr^2 + dS_{\text{sc}}^2$$

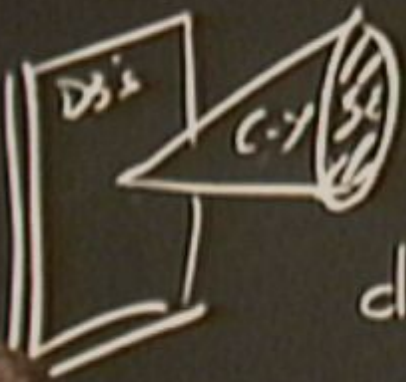


$$dS^2 = dr^2 + r^2 d\theta^2$$



$$dS_{cv}^2 = dr^2 + r^2 dS_{sc}^2$$

$$\frac{C-V}{R^6}$$

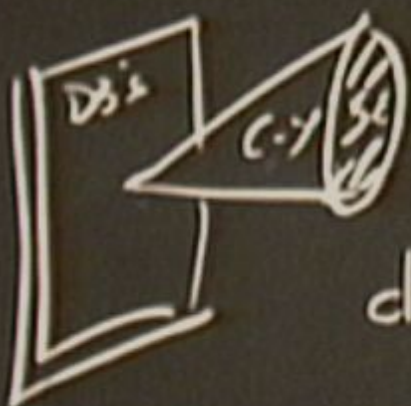


$$dS_{uv}^2 = dr^2 + r^2 dS_{Sc}^2$$

$$\frac{C-V}{R^6}$$

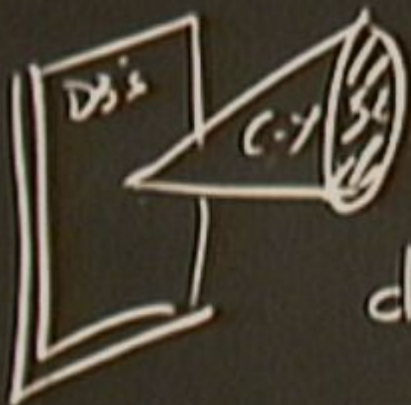
$$\frac{S \cdot C}{S^5}$$

$$\rightarrow N = 4SYM$$



$$dS_{cv}^2 = dr^2 + r^2 dS_{sc}^2$$

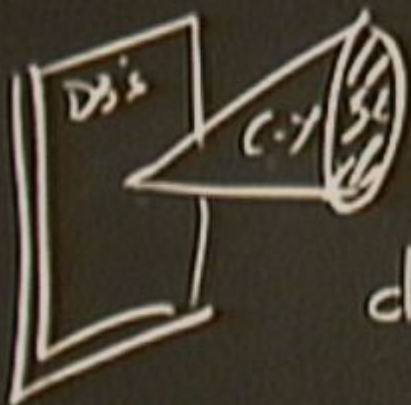
$\frac{C-V}{R^6}$	$\frac{S.C}{S^5}$	$\rightarrow N=4SYM$
Gonifald	T''	$\rightarrow KW$



$$dS_{cy}^2 = dr^2 + r^2 dS_{S^1}^2$$

$$dS_{ge}^2 = dS_{KE}^2 + (d\tau + A_{KE})^2$$

$\frac{C-V}{R^6}$	$\frac{S \cdot C}{S^5}$	$\rightarrow N=4 \text{ SW}$
Gonifol	T^{11}	$\rightarrow K$

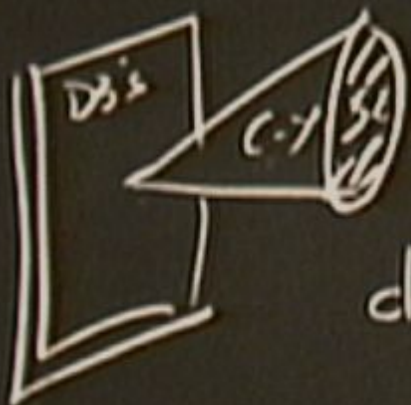


$$dS_{cy}^2 = dr^2 + r^2 dS_{S^2}^2$$

$$dS_{ge}^2 = dS_{KE}^2 + (d\tau + A_{KE})^2$$

$$dA_{KE} = \text{I}_{KE}$$

$\frac{C-V}{R^6}$	$\frac{S \cdot C}{S^5}$	$\rightarrow N=4s$
Gonifol	T''	$\rightarrow KW$

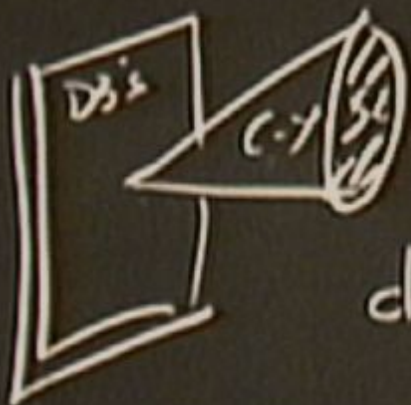


$$dS_{cy}^2 = dr^2 + r^2 dS_{Se}^2$$

$$dS_{Se}^2 = dS_{KE}^2 + (d\tau + A_{KE})^2$$

$$dA_{KE} = 2\mathcal{I}_{KE}$$

$\frac{C-V}{R^6}$	$\frac{S \cdot C}{S^5}$	$\rightarrow \mathcal{N} = 4 \text{SYM}$
Gonifol	T^{11}	$\rightarrow \text{KW}$

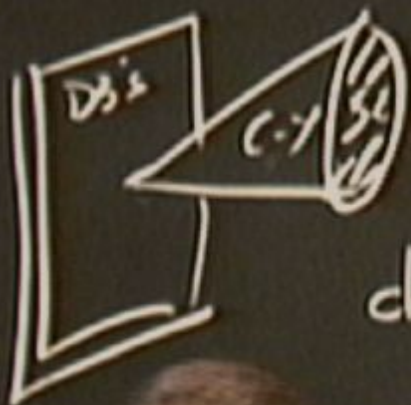


$$dS_{cy}^2 = dr^2 + r^2 dS_{SE}^2$$

$$dS_{SE}^2 = dS_{KE}^2 + (\underline{d\tau} + A_{KE})^2$$

$$dA_{KE} = 2\mathcal{I}_{KE}$$

$\frac{C-V}{R^6}$	$\frac{S \cdot C}{S^5}$	$\rightarrow$	SYM
Gonifold	T^{11}		W



$$dS_{ge}^2 = dS_{KE}^2 + (\underline{d\tau} \cdot A_{KE})^2$$

$$dA_{KE} = 2I_{KE}$$

$$dS_{ev}^2 = dr^2 + r^2 dS_{ge}^2$$

S.C

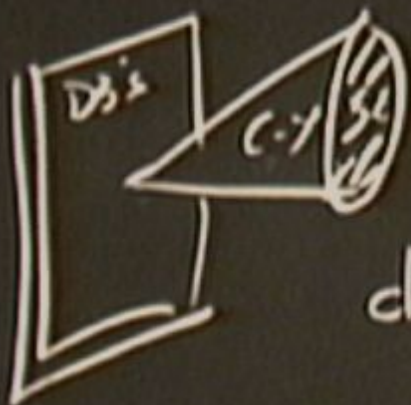
S⁵

→ N = 4SYM

KC

T¹¹

→ KW

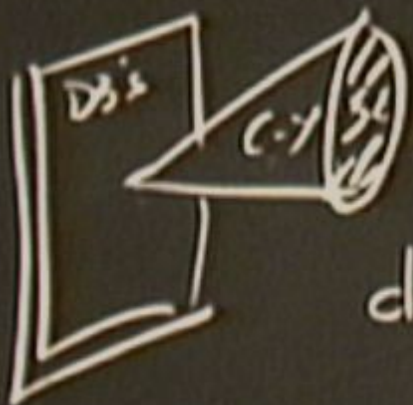


$$dS_{C-V}^2 = dr^2 + r^2 dS_{S^2}^2$$

$$dS_{S^2}^2 = dS_{KE}^2 + \left(\frac{d\tau}{r} A_{KE} \right)^2$$

$$dA_{KE} = 2\tau dr$$

$\frac{C-V}{R^6}$	$\frac{S-C}{S^5}$	$\rightarrow N=4SYM$	$\frac{X-C}{CP^2}$
Gonifald	T^{11}	$\rightarrow KW$	$S^2 \times S^2$



$$dS_{cv}^2 = dr^2 + r^2 dS_{sc}^2$$

$$dS_{ge}^2 = dS_{KE}^2 + (\underline{d\tau} + A_{KE})^2$$

$$dA_{KE} = 2\overline{I}_{KE}$$

$\frac{C-V}{R^6}$	$\frac{S \cdot C}{S^5}$	$\rightarrow N=4SYM$	$\frac{X \cdot C}{CP^2}$
Conifold	$T^{1,1}$	$\rightarrow KW$	$S^2 \times S^2$

$$ds^2 = h^{\frac{1}{2}}(r) \left(-b(r) dt^2 + d\vec{x}^2 \right) + \frac{h^{\frac{1}{2}}(r) (F(r) s^2)^2}{b(r)} dr^2 + R^2 \left[(d\psi + A_{\psi})^2 \right]$$

$\frac{C-V}{R^6}$	$\frac{S-C}{S^5}$	
Gonifol	T''	$\rightarrow N=4SYM$
		$\rightarrow KW$

$$ds^2 = h^{\frac{1}{2}}(r) \left(-b(r) dt^2 + d\vec{x}^2 \right) + \frac{h^{\frac{1}{2}}(r) (F(r) S(r))^2}{b(r)} dr^2 + R^2 \left[S(r) d\Omega_{S^2}^2 + F(r) (dz + A_{U(1)})^2 \right]$$

$\frac{C-V}{R^6}$	$\frac{C \cdot C}{R^6}$		$\frac{X \cdot C}{CP^2}$
Gonif		$\rightarrow N=4SYM$	$S^2 \times S^2$
		$\rightarrow KW$	

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F(r) S(r))^2}{b(r)} dr^2 + R^2 [S(r) d\vec{x}_{S^2}^2 + F(r) (dz + A_{U(1)})^2]$$

$$F(r) = (1+x) \mathcal{E}(x)$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F(r) \sin^2 \theta)^2}{b(r)} dr^2 + R^2 [\sin^2 \theta d\phi^2 + F(r) (dz + A_\phi d\phi)^2]$$

$$F(r) = (1+x) \mathcal{E}(x)$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F(r) \sin^2 \theta)^2}{b(r)} dr^2 + R^2 [\sin^2 \theta d\phi^2 + F(r) (dz + A_\phi d\phi)^2]$$

$$F(r) = Q^2 (1 + \kappa) \mathcal{E}(R_0)$$

$$F(r) =$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F(r) \sin^2 \theta)^2}{b(r)} dr^2 + R^2 [\sin^2 \theta d\phi^2 + F(r) (dz + A(r) d\phi)^2]$$

$$F(r) = Q_L^2 (1 + \kappa) \mathcal{E}(X_0)$$

$$F(r) = Q_L$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F(r) \sin^2 \theta)^2}{b(r)} dr^2 + R^2 [\sin^2 \theta d\phi^2 + F(r) (dz + A_{\phi} d\phi)^2]$$

$$F(r) = Q_L^2 (1 + \kappa) \mathcal{E}(\mathcal{E}_0)$$

$$F(r) = Q_L^2 (dz + A_{\phi})$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F(r) \sin^2 \theta)^2}{b(r)} dr^2 + R^2 [\sin^2 \theta d\phi^2 + F(r) (d\tau + A_{\phi})^2]$$

$$F(r) = Q_L^2 (1+x) \mathcal{E}(x_0)$$

$$F(r) = Q_L (d\tau + A_{\phi})$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F(r) \sin^2 \theta)^2}{b(r)} dr^2 + R^2 [\sin^2 \theta d\phi^2 + F(r) (dz + A_{\phi})^2]$$

$$F(r) = Q_L^2 (1+x) \mathcal{E}(x)$$

$$F(r) = Q_L (dz + A_{\phi})$$

$$\phi = \phi(r)$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F(r) \sin^2 \theta)^2}{b(r)} dr^2 + R^2 [\sin^2 \theta d\phi^2 + F(r) (dz + A_{\phi} d\phi)^2]$$

$$F(r) = Q_L^2 (1+x) \mathcal{E}(x)$$

$$F(r) = Q_L^2 (dz + A_{\phi})$$

$$\phi = \phi(r)$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F(r) \sin^2 \theta)^2}{b(r)} dr^2 + R^2 \left[\sin^2 \theta d\phi^2 + F(r) (dz + A_\phi)^2 \right]$$

$$F(r) = Q_e^2 (1 + \kappa) \mathcal{E}(\Sigma_0)$$

$$F_{(1,1)} = Q_e (dz + A_\phi) \quad dF_{(1,1)} = 2Q_e J_{KE}$$

$$\phi =$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F(r) \sin^2 \theta)^2}{b(r)} dr^2 + R^2 [\sin^2 \theta d\phi^2 + F(r) (dz + A_{\phi} d\phi)^2]$$

$$F(r) = Q_f^2 (1+x) \mathcal{E}(x)$$

$$F_{(1)} = Q_f (dz + A_{\phi}) \quad dF_{(1)} = 2Q_f J_{\text{KE}}$$

$$\phi = \phi(r)$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F(r) \sin^2 \theta)^2}{b(r)} dr^2 + R^2 [\sin^2 \theta d\phi^2 + F(r) (dz + A_{\phi} d\phi)^2]$$

$$F(r) = Q_f^2 (1+x) \mathcal{E}(x)$$

$$F(r) = Q_f (dz + A_{\phi}) \rightarrow dF(r) = ? Q_f J_{\phi}$$

$$\phi = \phi(r)$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F(r) s^2)}{b(r)} dr + R^2 [S^2 d\vec{x}_{\text{MC}}^2 + f(r) (dz + A_{MC})^2]$$

$$F(r) = Q_f^2 (1+x) \mathcal{E}(x)$$

$$F(r) = Q_f (dz + A_{MC}) \rightarrow dF(r) = ? Q_f J_{MC}$$

$$\phi = \phi(r)$$

$$r < \underline{r_x} \leq r_n$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F(r) \sin^2 \theta)^2}{b(r)} dr^2 + R^2 [\sin^2 \theta d\phi^2 + F(r) (dz + A_{\phi})^2]$$

$$F(r) = Q_f^2 (1+x) \mathcal{E}(x)$$

$$F(r) = Q_f (dz + A_{\phi}) \rightarrow dF(r) = ? Q_f J_{A\phi}$$

$$\phi = \phi(r)$$

$$r < r_* \leq r_{\text{ch}}$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F(r) \sin^2 \theta)^2}{b(r)} dr^2 + R^2 [\sin^2 \theta d\phi^2 + F(r) (dz + A_{\phi} d\phi)^2]$$

$$F(r) = Q_f^2 (1+x) \mathcal{E}(x)$$

$$F(r) = Q_f (dz + A_{\phi}) \rightarrow dF(r) = ? Q_f J_{\phi}$$

$$\phi = \phi(r)$$

$$\underline{r < r_* \leq r_h}$$



$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F(r) \sin^2 \theta)^2}{b(r)} dr^2 + R^2 [\sin^2 \theta d\phi^2 + F(r) (dz + A_{\mu\nu})^2]$$

$$F(r) = Q_f^2 (1+x) \mathcal{E}(x)$$

$$F(r) = Q_f (dz + A_{\mu\nu}) \rightarrow dF(r) = ? Q_f J_{\mu\nu}$$

$$\phi = \phi(r)$$

$$\underline{r < r_x \leq r_n}$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F(r) S(r))^2}{b(r)} dr + R^2 [S(r) d\vec{x}_{\text{hor}}^2 + F(r) (dz + A_{\text{hor}})^2]$$

$$F(r) = Q_f^2 (1+x) \mathcal{E}(x_0)$$

$$F(r) = Q_f (dz + A_{\text{hor}}) \rightarrow dF(r) = ? Q_f J_{\text{hor}}$$

$$\phi = \phi(r)$$

$$\underline{r < r_* \leq r_{\text{ch}}}$$

$$ds^2 = h^{\mu\nu}(r) \left(-b(r) dt^2 + d\vec{x}^2 \right) + \frac{h^{\mu\nu}(r) (r(r) s(r))^2}{b(r)} dr^2 + R^2 \left[S(r) d\Omega_{S^2}^2 + F(r) (dz + A_{\text{vec}})^2 \right]$$

$$F(r) = Q_f^2 (1+x) \mathcal{E}(x)$$

$$F(r) = Q_f (d\tau + A_{\text{vec}}) \rightarrow dF(r) = ? Q_f J_{\text{vec}}$$

$$\phi = \phi(r)$$

$$r < (r_*) \leq r_{\text{LD}} \\ \sum_{\text{vec}} \Lambda_{\text{vec}}$$

$$ds^2 = h^{\mu\nu}(r) \left(-b(r) dt^2 + d\vec{x}^2 \right) + \frac{h^{\mu\nu}(r) (r(r) s(r))^2}{b(r)} dr^2 + R^2 \left[S_{\mu\nu}^2 ds_{\mu\nu}^2 + F_{\mu\nu} (dz + A_{\mu\nu})^2 \right]$$

$$F_{\mu\nu} = Q_L (1+x) \mathcal{E}(X_3)$$

$$F_{\mu\nu} = Q_L (d\tau + A_{\mu\nu}) \rightarrow dF_{\mu\nu} = ? Q_L J_{\mu\nu}$$

$$\phi = \phi(r)$$

$$r < \underbrace{(r_*)}_{\sim \Lambda_w} \leq r_{LD}$$

$$ds^2 = h^{\mu\nu}(r) \left(-b(r) dt^2 + d\vec{x}^2 \right) + \frac{h^{\mu\nu}(r) (F(r) S(r))^2}{b(r)} dr^2 + R^2 \left[S(r) d\vec{x}_{\text{MC}}^2 + F(r) (dz + A_{\text{MC}})^2 \right]$$

$$F(r) = Q_f^2 (1+x) \mathcal{E}(x)$$

$$F(r) = Q_f (d\tau + A_{\text{MC}}) \rightarrow dF(r) = ? Q_f J_{\text{MC}}$$

$$\phi = \phi(r)$$

$$r < \underbrace{(r_*)}_{\text{KW}} \leq r_{\text{LD}}$$

$$\frac{\Delta_{\text{IR}}}{\Delta}$$

$$ds^2 = h^{\mu\nu}(r) \left(-b(r) dt^2 + d\vec{x}^2 \right) + \frac{h^{\mu\nu}(r) (r(r) s(r))^2}{b(r)} dr^2 + R^2 \left[S(r) d\Omega_{S^2}^2 + F(r) (dz + A_{\text{vec}})^2 \right]$$

$$F(r) = Q_f^2 (1+x) \mathcal{E}(x)$$

$$F(r) = Q_f (d\tau + A_{\text{vec}}) \rightarrow dF(r) = ? Q_f J_{\text{vec}}$$

$$\phi = \phi(r)$$

$$r < \underline{\underline{r_*}} \leq r_{\text{LD}}$$

$$\frac{\Delta_{\text{IR}}}{\Delta_{\text{UV}}}$$

$$ds^2 = h^{\mu\nu}(r) \left(-b(r) dt^2 + d\vec{x}^2 \right) + \frac{h^{\mu\nu}(r) (r(r) s(r))^2}{b(r)} dr^2 \left[S(r) ds_{\text{MC}}^2 + F(r) (dz + A_{\text{MC}})^2 \right]$$

$$F(r) = Q_f^2 (1+x) \mathcal{E}(x)$$

$$F(r) = Q_f (dT + A_{\text{MC}}) \rightarrow dF(r) = ? Q_f J_{\text{MC}}$$

$$\phi = \phi(r)$$

$$r < \underbrace{(r_*)}_{\text{CP}} \leq r_{\text{LD}}$$

$$\frac{\Lambda_{\text{IR}}}{\Lambda_{\text{UV}}}$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (f(r) s(r))^2}{b(r)} dr^2 + R^2 [S(r) d\Omega_{S^2}^2 + F(r) (dz + A_{\text{vec}})^2]$$

$$F(r) = Q_L^2 (1+x) \mathcal{E}(\vec{x}_0)$$

$$F_{(1)} = Q_L (d\tau + A_{\text{vec}}) \rightarrow dF_{(1)} = ? Q_L J_{\text{vec}}$$

$$\phi = \phi(r)$$

$$r < \underbrace{(r_x)}_{\text{}} < r_{\text{cd}}$$

$$\frac{\Lambda_{\text{IR}}}{\Lambda_{\text{UV}}}$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (f(r) s^2)}{b(r)} dr^2 + R^2 [S^2_{\text{MC}} + F(r) (dz + A_{\text{MC}})^2]$$

$$F(r) = Q_L^2 (1+x) \mathcal{E}(\vec{x}_0)$$

$$F(r) = Q_L (d\tau + A_{\text{MC}}) \rightarrow dF(r) = ? Q_L J_{\text{MC}}$$

$$\phi = \phi(r)$$

$$r < \underbrace{(r_x)}_{\text{MC}} < r_{\text{CD}}$$

$$\frac{\Lambda_{\text{IR}}}{\Lambda_{\text{UV}}}$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (r(r) s(r))^2}{b(r)} dr^2 + R^2 [S(r) d\Omega_{n-1}^2 + F(r) (dz + A_{n-1})^2]$$

$$F(r) = Q_L^2 (1+x) \mathcal{E}(x)$$

$$F(r) = Q_L (d\tau + A_{KE}) \rightarrow dF(r) = ? Q_L J_{KE}$$

$$\phi = \phi(r)$$

$$r < \underbrace{(r_x)}_{\text{KW}} < r_{LD}$$

$$\frac{\Lambda_{IR}}{\Lambda_{UV}}$$

hep-th/0602118

$$\phi_{-1:0} = \phi_\lambda - \log(1 + C_\star(p_\lambda - p))$$



lep-th/0608118

$$\phi_{T=0} = \phi_A - \log\left(1 + \frac{C_*}{T} (p_A - p)\right)$$

$\downarrow$
 $Q_1 e^{\phi_A}$

$$-\infty < p < 0$$

lep. th / 06/11/18

$$\Phi_{\gamma=0} = \Phi_\lambda - \log \left(1 + \underbrace{C_\star}_{O(e^{\frac{1}{2}\lambda})} (p_\lambda - p) \right)$$

$$-\infty < p < 0$$

$$p_{LP} = p_\lambda + C_\star^{-1}$$

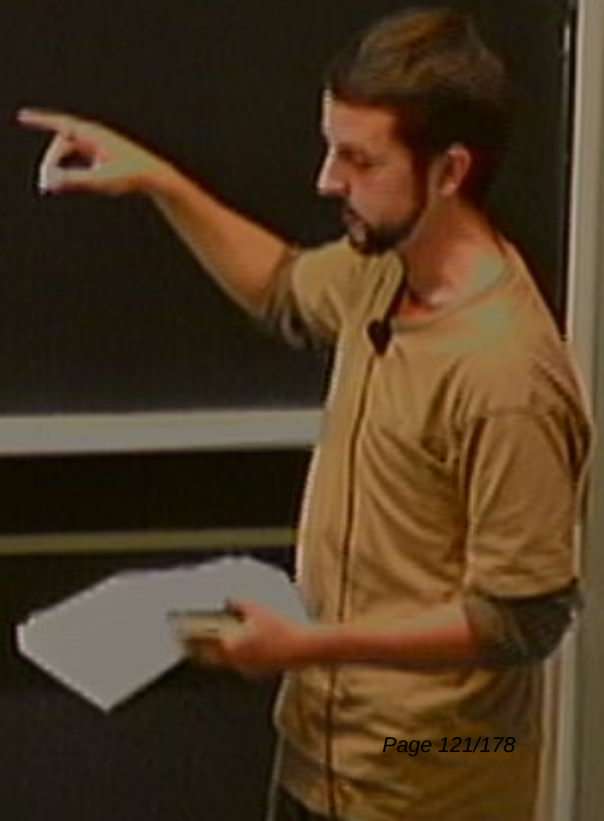
lep. th / 06/12/18

$$\Phi_{\gamma=0} = \Phi_\lambda - \log\left(1 + \underbrace{C_\star}_{O(e^{\frac{1}{2}\lambda})} (p_\lambda - p)\right)$$

$$-\infty < p < 0_{uv}$$

$$p_{LP} = p_\lambda + C_\star^{-1} \rightarrow C_\star \ll 1$$

$$O(e^{\frac{1}{2}\lambda})$$



lep. th / 06.12.118

$$\Phi_{\gamma=0} = \Phi_\lambda - \log \left(1 + \underbrace{C_\star}_{\Omega_f e^{\Phi_\lambda}} (p_\lambda - p) \right) \quad -\infty < p < 0_{uv}$$

$$p_{LP} : p_\lambda + \epsilon_\lambda^{-1} \rightarrow \epsilon_\lambda \ll 1$$

$$\Omega_f e^{\Phi_\lambda} = \frac{V_1(\gamma_\lambda)}{8\pi V_1(\gamma_\lambda)} \lambda_\lambda \frac{H_f}{N_f}$$

rep. th/0612118

$$\phi_{y=0} = \phi_n - \log\left(1 + \underbrace{C_n}_{\Omega_1 e^{\phi_n}} (p_n - p)\right)$$

$$-\infty < p < 0$$

$$p_{LP} = p_n + \epsilon_n^{-1} \rightarrow \epsilon_n \ll 1$$

$$\Omega_1 e^{\phi_n} = \frac{V_1(x_n)}{4\pi V_1(x_n)} \lambda_n \frac{N_f}{N}$$

lep. th / 0612118

$$\phi_{\gamma,0} = \phi_\gamma - \log \left(1 + \frac{C_\gamma (p_\gamma - p)}{\omega_\gamma e^{\phi_\gamma}} \right)$$

$$-\infty < p < 0_{uv}$$

$$p_{LP} = p_\gamma + \epsilon_\gamma^{-1} \rightarrow \epsilon_\gamma \ll 1$$

$$\omega_\gamma e^{\phi_\gamma} = \frac{V_1(\beta_s)}{16\pi V_1(\chi_s)} \lambda_\gamma \frac{N_\gamma}{N}$$

$$\lambda_\gamma = 4\pi g_s e^{\phi_\gamma}$$

lep. th / 06.12.118

$$\Phi_{\gamma=0} = \Phi_{\lambda} - \log \left(1 + \underbrace{C_{\gamma}}_{\omega_f e^{\Phi_{\lambda}}} (p_{\lambda} - p) \right)$$

$$-\infty < p < 0$$

$$p_{LD} = p_{\lambda} + \epsilon_{\lambda}^i \rightarrow \epsilon_{\lambda} \ll 1$$

$$\omega_f e^{\Phi_{\lambda}} = \frac{V_{\lambda}(x_s)}{16\pi V_{\lambda}(x_0)} \lambda_{\lambda} \frac{N_f}{N}$$

$$\lambda_{\lambda} = 4\pi g_s e^{\Phi_{\lambda}}$$

$$\downarrow$$

$$\lambda_H = 4\pi g_s e^{\Phi_H}$$

hep-th/0612118

$$\phi_{-1:0} = \phi_\lambda - \log\left(1 + \frac{C_*}{\omega_1 e^{\phi_\lambda}} (r_\lambda - r)\right)$$

$$-\infty < r < 0_{uv}$$

$$r_{LD} = r_\lambda + \epsilon_\lambda^{-1} \rightarrow \epsilon_\lambda \ll 1$$

— Reg. horizon

$$\omega_1 e^{\phi_\lambda} = \frac{V_1(x_s)}{4\pi V_1(x_h)} \lambda_\lambda \frac{N_c}{N_f}$$

$$\lambda_v = 4\pi g_s e^{\phi_v}$$

$$\lambda_H = 4\pi g_s e^{\phi_H}$$

hep-th/0608118

$$\Phi_{\tau=0} = \Phi_\lambda - \log\left(1 + \frac{C_\star}{T} (r_\lambda - r)\right) \quad -\infty < r < 0_{uv}$$

$\downarrow$
 $\Omega_f e^{\Phi_\lambda}$

$$r_{LD} = r_\lambda + C_\star^{-1} \rightarrow C_\star \ll 1$$

— Reg. horizon

$$r_\lambda \rightarrow g_{\mu\nu}(r_r)|_T \rightarrow g_{\mu\nu}(r_\lambda)|_{T=0}$$

$$\Omega_f e^{\Phi_\lambda} = \frac{V_4(\mathcal{S}_3)}{8\pi^2 V_4(\mathcal{X}_6)} \lambda_\star \frac{N_f}{N_c}$$

$$\lambda_\star = 4\pi g_s e^{\Phi_\lambda}$$

$$\lambda_H = \frac{1}{\lambda_\star} 4\pi g_s e^{\Phi_H}$$

hep-th/0602118

$$\phi_{\text{reg}} = \phi_\star - \log\left(1 + \frac{e_\star}{\omega_1 e^{\phi_\star}} (r_\star - r)\right) \quad -\infty < r < 0_{\text{UV}}$$

$$r_{\text{LD}} = r_\star + e_\star^{-1} \rightarrow e_\star \ll 1$$

— Reg. horizon

$$r_\star \rightarrow g_{\mu\nu}(r_r)|_r \rightarrow g_{\mu\nu}(r_\star)|_{r=0}$$

$$g_{tt} = 1 - \frac{2M}{r} \rightarrow 1$$

$$\omega_1 e^{\phi_\star} = \frac{V_1(x_\star)}{4\pi r V_A(x_\star)} \lambda_\star \frac{N_f}{N}$$

$$\lambda_\star = 4\pi g_5 e^{\phi_\star}$$

$$\lambda_H = 4\pi g_5 e^{\phi_H}$$

rep. th/061118

$$\phi_{-1:0} = \phi_\lambda - \log\left(1 + \frac{e_\lambda (r_\lambda - r)}{\omega_f e^{\phi_\lambda}}\right)$$

$$-\infty < r < 0_{uv}$$

$$r_{LP} = r_\lambda + e_\lambda \rightarrow e_\lambda \ll 1$$

— Reg. horizon

$$r_\lambda \rightarrow g_{\mu\nu}(r_r)|_r \rightarrow g_{\mu\nu}(r_\lambda)|_{r=0}$$

$$g_{tt} = 1 - \left(\frac{r_\lambda^4}{r^4}\right) = 1$$

$$\omega_f e^{\phi_\lambda} = \frac{V_\lambda(x_s)}{8\pi V_\lambda(x_h)} \lambda_\lambda \frac{N_f}{N}$$

$$\lambda_v = 4\pi g_s e^{\phi_\lambda}$$

$$\lambda_H = 4\pi g_s e^{\phi_\lambda}$$

rep. th/061118

$$\Phi_{\gamma=0} = \Phi_\star - \log\left(1 + \frac{C_\star (r_\star - r)}{\omega_1 e^{\Phi_\star}}\right) \quad -\infty < r < 0_{uv}$$

$$r_{LP} = r_\star + \epsilon_\star^{-1} \rightarrow \epsilon_\star \ll 1$$

— Reg. horizon

$$r_\star \rightarrow g_{\mu\nu}(r_r)|_r \rightarrow g_{\mu\nu}(r_\star)|_{r=0}$$

$$g_{tt} = 1 - \left(\frac{r_H^4}{r_\star^4}\right) = 1$$

$$\omega_1 e^{\Phi_\star} = \frac{V_H(X_\star)}{8\pi T V_H(X_\star)} \lambda_\star \frac{N_f}{N}$$

$$\lambda_\star = 4\pi g_s e^{\Phi_\star}$$

$$\lambda_H = 4\pi g_s e^{\Phi_H}$$

rep. th/06/11/18

$$\phi_{r=0} = \phi_\lambda - \log\left(1 + \underbrace{C_*}_{\Omega_1 e^{\phi_\lambda}} (r_\lambda - r)\right) \quad -\infty < r < 0_{uv}$$

$$r_{LP} = r_\lambda + \epsilon_\lambda^{-1} \rightarrow \epsilon_\lambda \ll 1$$

— Reg. horizon

$$r_\lambda \rightarrow g_{\mu\nu}(r_r) \Big|_r \rightarrow g_{\mu\nu}(r_\lambda) \Big|_{r=0}$$

$$g_{tt} = 1 - \left(\frac{r_H}{r_\lambda}\right)^4 = 1$$

$$\Omega_1 e^{\phi_\lambda} = \frac{V_H(\mathcal{S}_\lambda)}{4\pi r V_H(\mathcal{X}_\lambda)} \lambda_\lambda \frac{N_f}{N_c}$$

$$\lambda_\lambda = 4\pi g_s e^{\phi_\lambda}$$

$$\lambda_H = 4\pi g_s e^{\phi_H}$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F(r) S(r))^2}{b(r)} dr + R^2 [S(r) d\vec{x}_{\text{MC}}^2 + F(r) (dz + A_{MC})^2]$$

$$F(r) = Q_L^2 (1+x) \mathcal{E}(x)$$

$$F(r) = Q_L (dz + A_{MC}) \rightarrow dF(r) = ? Q_L J_{MC}$$

$$\phi = \phi(r)$$

$$r < (r_x) < r_{LD}$$

$$\frac{\Lambda_{IR}}{\Lambda_{UV}}$$

$$dA_{MC} = h = \frac{R^2}{r^2}$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F_{\mu\nu} S^{\mu\nu})^2}{b(r)} dr^2 + R^2 [S^2(r) d\Omega_{S^2}^2 + F(r) (dz + A_{\mu\nu})^2]$$

$$F(r) = Q_L^2 (1+x) \mathcal{E}(x)$$

$$dA_{\mu\nu} = h = \frac{R^4}{r^4}$$

$$F_{(1)} = Q_L (dz + A_{\mu\nu}) \rightarrow dF_{(1)} = ? Q_L J_{AE}$$

$$\phi = \phi(r)$$

$$r < (r_x) < r_{Ln}$$

$$\frac{\Lambda_{IR}}{\Lambda_{UV}}$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F_{\mu\nu} S^{\mu\nu})^2}{b(r)} dr^2 + R^2 [S^2(r) d\Omega_{S^2}^2 + F(r) (dz + A_{\text{vec}})^2]$$

$$F(r) = Q_L^2 (1+x) \mathcal{E}(x)$$

$$F_{(1)} = Q_L (dz + A_{\text{vec}}) \rightarrow dF_{(1)} = ? Q_L J_{\text{vec}}$$

$$\phi = \phi(r)$$

$$r < (r_x) < r_{\text{LD}}$$

$$\frac{\Lambda_{\text{IR}}}{\Lambda_{\text{UV}}}$$

$$dA_{\text{vec}} \quad h = \frac{R^4}{r^4}$$

$$b = 1 - \frac{r_H^2}{r^2}$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F_{\mu\nu} S^{\mu\nu})^2}{b(r)} dr^2 + R^2 [S^2(r) d\Omega_{S^2}^2 + F(r) (dz + A_{\text{vec}})^2]$$

$$F(r) = Q_L^2 (1+x) \mathcal{E}(X_0)$$

$$F(r) = Q_L (dz + A_{\text{vec}}) \rightarrow dF(r) = ? Q_L J_{\text{vec}}$$

$$\phi = \phi(r)$$

$$r < (r_x) < r_{\text{Ln}}$$

$$\frac{\Lambda_{\text{IR}}}{\Lambda_{\text{UV}}}$$

$$dA_{\text{vec}} \quad h = \frac{R^4}{r^4}$$

$$b = 1 - \frac{r_{\text{H}}^2}{r^2}$$

rep. th/0612118

$$\Phi_{\gamma=0} = \Phi_\lambda - \log\left(1 + \underbrace{C_*}_{\Omega_1 e^{\Phi_\lambda}} (p_\lambda - p)\right) \quad -\infty < p < 0_w$$

$$p_{LP} = p_\lambda + \epsilon_\lambda^{-1} \rightarrow \epsilon_\lambda \ll 1$$

— Reg. horizon

$$\begin{aligned} \text{— } r_* \rightarrow g_{\mu\nu}(r_*)|_{\Gamma} &\rightarrow g_{\mu\nu}(r_*)|_{\Gamma=0} \\ &\downarrow \quad \downarrow \\ g_{tt} &= 1 - \left(\frac{r_H^4}{r_*^4}\right) = 1 \end{aligned}$$

$$\epsilon_\lambda = \Omega_1 e^{\Phi_\lambda} = \frac{V_1(x_s)}{4\pi V_1(x_s)} \lambda_\lambda \frac{N_f}{N}$$

$$\lambda_\nu = 4\pi g_s e^{\Phi_\lambda}$$

$$\downarrow$$

$$\lambda_H = 4\pi g_s e^{\Phi_\lambda}$$

rep. th/0612118

$$\phi_{\gamma=0} = \phi_\lambda - \log\left(1 + \underbrace{C_*}_{\Omega_1 e^{\phi_\lambda}} (r_\lambda - r)\right) \quad -\infty < r < 0_w$$

$$r_{LP} = r_\lambda + \epsilon_\lambda^{-1} \rightarrow \epsilon_\lambda \ll 1$$

— Reg. horizon

$$r_\lambda \rightarrow g_{\mu\nu}(r_r) \Big|_r \rightarrow g_{\mu\nu}(r_\lambda) \Big|_{r=0}$$

$$g_{tt} \rightarrow 1 - \left(\frac{r_H^4}{r_\lambda^4}\right) = 1$$

$$\epsilon_\lambda = \Omega_1 e^{\phi_\lambda} = \frac{V_\lambda(x_s)}{4\pi V_\lambda(x_h)} \lambda_\lambda \frac{N_f}{N}$$

$$F = 1 - \mathcal{O}(\epsilon_r)$$

$$\lambda_\lambda = 4\pi\sigma_s e^{\phi_\lambda}$$

$$\lambda_H = 4\pi\sigma_s e^{\phi_H}$$

rep. th / 06/12/18

$$\phi_{r=0} = \phi_\star - \log\left(1 + \underbrace{C_\star}_{O(e^{\phi_\star})} (r_\star - r)\right) \quad -\infty < r < 0_w$$

$$r_{LP} = r_\star + \epsilon_\star^{-1} \rightarrow \epsilon_\star \ll 1$$

— Reg. horizon

$$r_\star \rightarrow g_{\mu\nu}(r_r) \Big|_r \rightarrow g_{\mu\nu}(r_\star) \Big|_{r=0}$$

$$g_{tt} \rightarrow 1 - \left(\frac{r_H^4}{r_\star^4}\right) = 1$$

$$\epsilon_\star = O(e^{\phi_\star}) = \frac{V_H(x_\star)}{4\pi V_H(x_0)} \lambda_\star \frac{N_f}{N}$$

$$F = 1 - O(\epsilon_r)$$

$$S = 1 + O(\epsilon_r)$$

$$\phi = \phi_\star + \dots$$

$$\lambda_\star = 4\pi g_s e^{\phi_\star}$$

$$\lambda_H = 4\pi g_s e^{\phi_H}$$

rep. th/0612118

$$\phi_{\tau=0} = \phi_x - \log\left(1 + \underbrace{C_*}_{O(e^{\phi_x})} (p_x - p)\right) \quad -\infty < p < 0_w$$

$$p_{LP} = p_x + \epsilon_x^{-1} \rightarrow \epsilon_x \ll 1$$

— Reg. horizon

$$r_* \rightarrow g_{\mu\nu}(r_*)|_T \rightarrow g_{\mu\nu}(r_*)|_{T=0}$$

$$g_{tt} = 1 - \left(\frac{r_H^4}{r_*^4}\right) = 1$$

$$\epsilon_x = O(e^{\phi_x}) = \frac{V_H(x_s)}{4\pi V_H(x_0)} \lambda_x \frac{N_f}{N}$$

$$F = 1 - O(\epsilon_r) + 0$$

$$S = 1 + O(\epsilon_r)$$

$$\phi = \phi_x + \dots$$

$$\lambda_x = 4\pi g_s e^{\phi_x}$$

$$\lambda_H = 4\pi g_s e^{\phi_H}$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F(r) S(r))^2}{b(r)} dr^2 + R^2 [S(r) d\vec{x}_{S^2}^2 + F(r) (dz + A_{U(1)})^2]$$

$$F(r) = Q_f (1+x) \mathcal{E}(X_0)$$

$$F(r) = Q_f (dz + A_{U(1)}) \rightarrow JF = ? Q_f J_{U(1)}$$

$$\phi = \phi(r)$$

$$r < (r_*) < r_{\text{ch}}$$

$$\frac{\Lambda_{\text{IR}}}{\Lambda_{\text{UV}}}$$

$$dA_{\text{hor}} \quad h = \frac{R^4}{r^4}$$

$$b = 1 - \frac{r_h^2}{r^2}$$

$$ds^2 = h^{\mu\nu}(r) (-b(r) dt^2 + d\vec{x}^2) + \frac{h^{\mu\nu}(r) (F(r) S(r))^2}{b(r)} dr^2 + R^2 [S(r) d\Omega_{S^2}^2 + F(r) (dz + A_{\text{vec}})^2]$$

$$F(r) = Q_f^2 (1+x) \mathcal{E}(x)$$

$$F(r) = Q_f (dz + A_{\text{vec}}) \rightarrow dF(r) = ? Q_f J_{\text{AE}}$$

$$\phi = \phi(r)$$

$$r < (r_x) < r_{\text{Ln}}$$

$$\frac{\Lambda_{\text{IR}}}{\Lambda_{\text{UV}}}$$

$$dA_{\text{vec}} \quad h = \frac{R^4}{r^4}$$

$$b = 1 - \frac{r_h^2}{r^2}$$

$$I_H \ll (I_A \ll I_B)$$

$$r_H \ll r_s \ll r_{L,D}$$

$$\epsilon_* \left| \log \frac{r_H}{r_s} \right| \ll 1 \rightarrow \frac{r_H}{r_s} \gg e^{-1/\epsilon_*}$$

$$r_H \ll r_s \ll r_{\text{eff}}$$

$$\epsilon_x \left| \log \frac{r_H}{r_x} \right| \ll 1 \rightarrow \frac{r_H}{r_x} \gg e^{-1/\epsilon_x}$$

$$e^{-1/\epsilon_x} \ll \frac{r_H}{r_x} \ll \epsilon_x \ll 1$$

$$r_h \ll r_s \ll r_{\text{Sch}}$$

$$\epsilon_x \left| \log \frac{r_h}{r_s} \right| \ll 1 \rightarrow \frac{r_h}{r_s} \gg e^{-1/\epsilon_x}$$

$$\underline{e^{-1/\epsilon_x} \ll \frac{r_h}{r_s} \ll \epsilon_x \ll 1}$$

$$r_h \ll r_s \ll r_{\text{ph}}$$

$$E_x \left| \log \frac{r_h}{r_x} \right| \ll 1 \rightarrow \frac{r_h}{r_x} \gg e^{-1/E_x}$$

$$e^{-1/E_x} \ll \frac{r_h}{r_x} \ll E_x \ll 1$$

$$r_H \ll r_s \ll r_{LH}$$

$$E_x \left| \log \frac{r_H}{r_x} \right| \ll 1 \rightarrow \frac{r_H}{r_x} \gg e^{-1/E_x}$$

$$e^{-1/E_x} \ll \frac{r_H}{r_x} \ll E_x \ll 1$$

$$N_c \gg 1$$

$$N_f \gg 1$$

$$\lambda_{11} \gg 1$$

$$l_H \ll r_a \ll r_{\text{cur}}$$

$$\epsilon_x \left| \log \frac{r_H}{r_x} \right| \ll 1 \rightarrow \frac{r_H}{r_x} \gg e^{-1/\epsilon_x}$$

$$e^{-1/\epsilon_x} \ll \frac{l_H}{r_x} \ll \epsilon_x \ll 1$$

$$\begin{array}{l} N_c \gg 1 \\ N_f \gg 1 \\ \lambda_H \gg 1 \end{array}$$

$$l_H \ll r_s \ll r_{\text{vir}}$$

$$\epsilon_X \left| \log \frac{r_H}{r_X} \right| \ll 1 \rightarrow \frac{r_H}{r_X} \gg e^{-1/\epsilon_X}$$

$$e^{-1/\epsilon_X} \ll \frac{r_H}{r_X} \ll \epsilon_X \ll 1$$

$$\begin{array}{l} N_c \gg 1 \\ N_f \gg 1 \\ \lambda_H \gg 1 \end{array}$$

$$r_H \ll r_* \ll r_{\text{LD}}$$

$$\epsilon_x \left| \log \frac{r_H}{r_x} \right| \ll 1 \rightarrow \frac{r_H}{r_x} \gg e^{-1/\epsilon_x}$$

$$e^{-1/\epsilon_x} \ll \frac{r_H}{r_x} \ll \epsilon_x \ll 1$$

$$\epsilon_H = 0.24$$

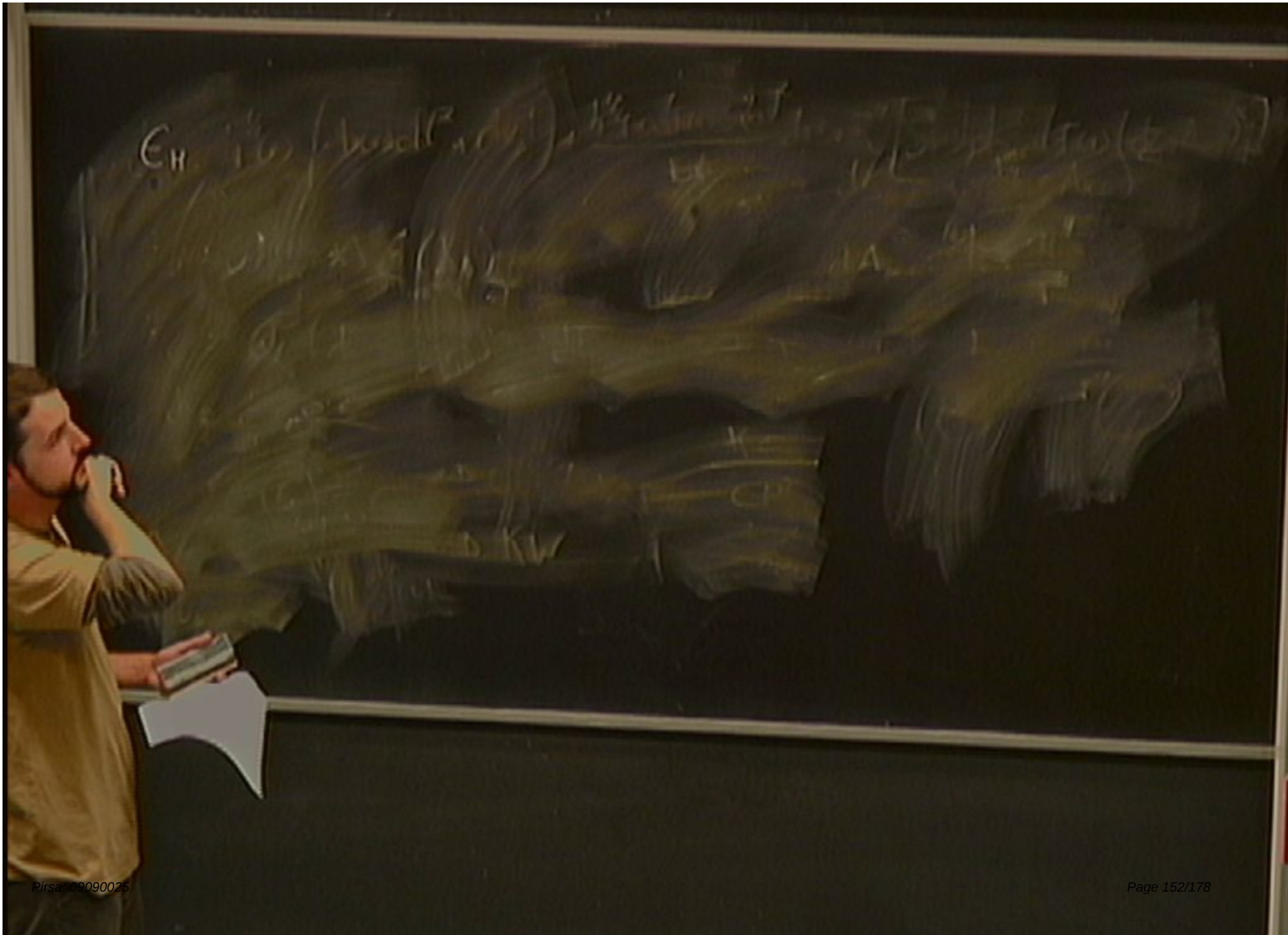
$$\begin{array}{l} N_c \gg 1 \\ N_f \gg 1 \\ \lambda_H \gg 1 \end{array}$$

$$l_H \ll r_s \ll r_{\text{vir}}$$

$$\epsilon_x \left| \log \frac{r_H}{r_x} \right| \ll 1 \rightarrow \frac{r_H}{r_x} \gg e^{-1/\epsilon_x}$$

$$e^{-1/\epsilon_x} \ll \frac{r_H}{r_x} \ll \epsilon_x \ll 1$$

$$\begin{array}{l} N_c \gg 1 \\ N_f \gg 1 \\ \lambda_H \gg 1 \end{array}$$



$$\epsilon_H = \epsilon_x + \epsilon_x \log\left(\frac{y_{t+1}}{y_t}\right)$$

$$\epsilon_H = \epsilon_s + \epsilon_s \log\left(\frac{r_{H1}}{r_s}\right) \rightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + O(\epsilon_H')$$



$$\epsilon_H = \epsilon_s + \epsilon_s \log\left(\frac{r_H}{r_s}\right) \rightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + O(\epsilon_H')$$

$$T = \frac{r_H}{\pi R} \left[1 - \frac{\epsilon_H}{8} - \frac{13}{384} \epsilon_H^2 + \dots \right]$$

$$\epsilon_H = \epsilon_s + \epsilon_s \log\left(\frac{r_{H1}}{r_s}\right) \rightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + O(\epsilon_H')$$

$$T = \frac{r_H}{\pi R^2} \left[1 - \frac{\epsilon_H}{8} - \frac{13}{384} \epsilon_H^2 + \dots \right]$$

$$S = \frac{S}{V_3}$$

$$\epsilon_H = \epsilon_s + \epsilon_s \log\left(\frac{V_{H0}}{V_s}\right) \rightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + O(\epsilon_H')$$

$$T = \frac{\epsilon_H}{\pi R^2} \left[1 - \frac{\epsilon_H}{8} - \frac{13}{384} \epsilon_H^2 + \dots \right]$$

$$\frac{S}{V_3} = \frac{\pi^5 N_c^2 T^3}{60}$$

$$\epsilon_H = \epsilon_* + \epsilon_* \log\left(\frac{r_{H1}}{r_*}\right) \rightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + \mathcal{O}(\epsilon_H')$$

$$T = \frac{r_H}{\pi R^2} \left[1 - \frac{\epsilon_H}{8} - \frac{13}{384} \epsilon_H^2 + \dots \right]$$

$$S = \frac{\pi^3 N_c^2 T^3}{2 \text{Vol}(\bar{X})} \left[1 + \frac{\epsilon_H}{2} \right]$$

$$\epsilon_H = \epsilon_s + \epsilon_s \log\left(\frac{r_H}{r_s}\right) \rightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + \mathcal{O}(\epsilon_H^2)$$

$$T = \frac{r_H}{\pi R^2} \left[1 - \frac{\epsilon_H}{8} - \frac{13}{384} \epsilon_H^2 + \dots \right]$$

$$S = \frac{S}{V_3} \frac{\pi^2 N_c^2 T^3}{2 \text{Vol}(\bar{X}_3)} \left[1 + \frac{\epsilon_H}{2} + \frac{7}{24} \epsilon_H^2 + \dots \right]$$

$$\epsilon_H = \epsilon_x + \epsilon_x \log\left(\frac{r_{H1}}{r_1}\right) \rightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + O(\epsilon_H^2)$$

$$T = \frac{r_{H1}}{\pi R^2} \left[1 - \frac{\epsilon_H}{8} - \frac{13}{384} \epsilon_H^2 + \dots \right]$$

$$S = \frac{S}{V_3} = \frac{\pi^3 N_c^2 T^3}{2 \text{Vol}(\bar{X}_3)} \left[1 + \frac{\epsilon_H}{2} + \frac{7}{24} \epsilon_H^2 + \dots \right]$$

$$\epsilon_H = \epsilon_x + \epsilon_x \log\left(\frac{r_{H1}}{r_1}\right) \rightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + O(\epsilon_H')$$

$$T = \frac{r_H}{\pi R^2} \left[1 - \frac{\epsilon_H}{8} - \frac{13}{384} \epsilon_H^2 + \dots \right]$$

$$S = \frac{S}{V_3} = \frac{\pi^3 N_c^2 T^3}{2 \text{Vol}(\bar{X}_3)} \left[1 + \frac{\epsilon_H}{2} + \frac{7}{24} \epsilon_H^2 + \dots \right]$$

$$\epsilon_H = \epsilon_s + \epsilon_s \log\left(\frac{r_H}{r_s}\right) \rightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + \mathcal{O}(\epsilon_H^2)$$

$$T = \frac{r_H}{\pi R^2} \left[1 - \frac{\epsilon_H}{8} - \frac{13}{384} \epsilon_H^2 + \dots \right]$$

$$\frac{S}{V_3} = \frac{\pi^3 N_c^2 T^3}{2 \text{Vol}(\bar{X}_3)} \left[1 + \frac{\epsilon_H}{2} + \frac{7}{24} \epsilon_H^2 + \dots \right]$$

$$\rightarrow \int_{r_s}^{r_H} \frac{1}{r^4} \sim \frac{r_H^3}{r_s^3} \sim \text{KW}$$

$$\epsilon_H = \epsilon_* + \epsilon_* \log\left(\frac{r_{H1}}{r_*}\right) \rightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + \mathcal{O}(\epsilon_H^2)$$

$$T = \frac{r_H}{\pi R^2} \left[1 - \frac{\epsilon_H}{8} - \frac{13}{384} \epsilon_H^2 + \dots \right]$$

$$S = \frac{S}{V_3} = \frac{\pi^3 N_c^2 T^3}{2 \text{Vol}(\bar{X}_3)} \left[1 + \frac{\epsilon_H}{2} + \frac{7}{24} \epsilon_H^2 + \dots \right]$$

$$\xi \rightarrow \int_{r_*}^{r_H} \frac{1}{r^4} \sim \left(\frac{r_{H1}}{r_*} \right) \text{ KW}$$

$$\epsilon_H = \epsilon_* + \epsilon_* \log\left(\frac{r_{H1}}{r_*}\right) \rightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + \mathcal{O}(\epsilon_H^2)$$

$$T = \frac{r_H}{\pi R^2} \left[1 - \frac{\epsilon_H}{8} - \frac{13}{384} \epsilon_H^2 + \dots \right]$$

$$= \frac{S}{V_3} = \frac{\pi^3 N_c^2 T^3}{2 \text{Vol}(\bar{X}_3)} \left[1 + \frac{\epsilon_H}{2} + \frac{7}{24} \epsilon_H^2 + \dots \right]$$

$$\rightarrow \int_{r_*}^{r_H} \frac{1}{r^4} \sim \left(\frac{r_{H1}}{r_*} \right) \sim \frac{\lambda_{H12}}{\lambda_{UV}}$$

$$\epsilon_H = \epsilon_* + \epsilon_* \log\left(\frac{V_{H1}}{V_*}\right) \rightarrow \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + \mathcal{O}(\epsilon_H^2)$$

$$T = \frac{\Gamma_H}{\pi R^2} \left[1 - \frac{\epsilon_H}{8} - \frac{13}{384} \epsilon_H^2 + \dots \right]$$

$$S = \frac{S}{V_3} = \frac{\pi^3 N_c^2 T^3}{2 V_0 I(\bar{\chi}_3)} \left[1 + \frac{\epsilon_H}{2} + \frac{7}{24} \epsilon_H^2 + \dots \right]$$

$$\frac{(\epsilon - 3p)}{T} \propto \epsilon_H^2 \quad \rightarrow \quad \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + \mathcal{O}(\epsilon_H^2)$$

$$S = \frac{S}{V_3} = \frac{\pi^2 N_c T^3}{2 \text{Vol}(\bar{X}_3)} \left[1 + \frac{\epsilon_H}{2} + \frac{7}{24} \epsilon_H^2 + \dots \right]$$

$\epsilon \rightarrow$

$$\frac{(\epsilon - 3P)}{T} \propto \epsilon_H^2 \quad \rightarrow \quad \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + O(\epsilon_H^2)$$

$$S = \frac{S}{V_3} = \frac{\pi^2 N_c T^3}{2 Vol(X_3)} \left[1 + \frac{\epsilon_H}{2} + \frac{7}{24} \epsilon_H^2 + \dots \right]$$

$\epsilon \rightarrow$

$$\frac{(\epsilon - 3P)}{T^4} \propto \epsilon_H^2 \quad \rightarrow \quad \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + \mathcal{O}(\epsilon_H^2)$$

$$V_S = \frac{S}{\epsilon_V} = \frac{1}{3} \left[1 + \frac{1}{6} \epsilon_H^2 \right]$$

$$S = \frac{S}{V_3} = \frac{\pi^2 N_c T^3}{2 V_0 I(\bar{\chi}_3)} \left[1 + \frac{\epsilon_H}{2} + \frac{7}{24} \epsilon_H^2 + \dots \right]$$

$\epsilon \rightarrow$

$$\frac{(\epsilon - 3P)}{T^4} \propto \epsilon_H^2 \quad \rightarrow \quad \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + \mathcal{O}(\epsilon_H^2)$$

$$V_S = \frac{S}{c_V} = \frac{1}{3} \left[1 + \frac{1}{6} \epsilon_H^2 \right] \quad \frac{\eta}{S} = \frac{1}{4\pi} + \left(\frac{r_H}{r_c} \right)''$$

$$\frac{S}{V_3} = \frac{\pi^3 N_c T^3}{2 \text{Vol}(\bar{X}_3)} \left[1 + \frac{\epsilon_H}{2} + \frac{7}{24} \epsilon_H^2 + \dots \right]$$

$$\frac{(\epsilon - 3P)}{T^4} \propto \epsilon_H^2 \quad \rightarrow \quad \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + \mathcal{O}(\epsilon_H^2)$$

$$V_S = \frac{S}{c_V} = \frac{1}{3} \left[1 + \frac{1}{6} \epsilon_H^2 \right] \quad \frac{\eta}{S} = \frac{1}{4\pi} + \left(\frac{r_H}{r_c} \right)''$$

$$S = \frac{S}{V_3} = \frac{\pi^2 N_c T^3}{2 V_0 I(\bar{\chi}_3)} \left[1 + \frac{\epsilon_H}{2} + \frac{7}{24} \epsilon_H^2 + \dots \right]$$

$$\epsilon \rightarrow \frac{g}{h} = 2 \left(V_S^2 - \frac{1}{3} \right)$$

$$\frac{(\epsilon - 3P)}{T^4} \propto \epsilon_H^2 \quad \rightarrow \quad \frac{d\epsilon_H}{dT} = \frac{\epsilon_H}{T} + O(\epsilon_H^2)$$

$$V_5 = \frac{S}{\epsilon_H} = \frac{1}{3} \left[1 + \frac{1}{6} \epsilon_H^2 \right] \quad \frac{\eta}{S} = \frac{1}{4\pi T} + \left(\frac{r_H}{r_c} \right)''$$

$$S = \frac{S}{V_3} = \frac{\pi^2 N_c^2 T^3}{2 \text{Vol}(\bar{X}_3)} \left[1 + \frac{\epsilon_H}{2} + \frac{7}{24} \epsilon_H^2 + \dots \right]$$

$$\epsilon \rightarrow \frac{g}{h} = 2 \left(V_5^2 - \frac{1}{3} \right)$$

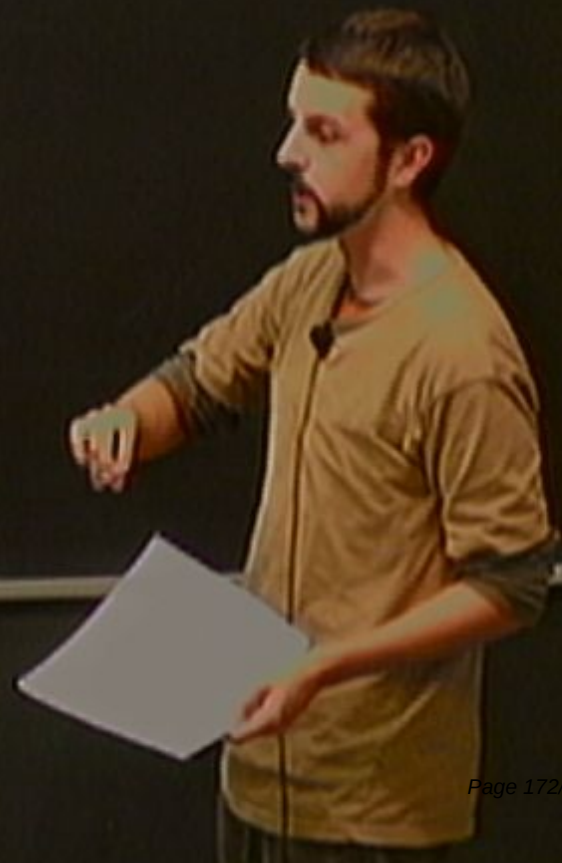
$$r_H \ll r_s \ll r_{\text{ED}}$$

$$\epsilon_x \left| \log \frac{r_H}{r_x} \right| \ll 1 \rightarrow \frac{r_H}{r_x} \gg e^{-1/\epsilon_x}$$

$$e^{-1/\epsilon_x} \ll \frac{r_H}{r_x} \ll \epsilon_x \ll 1$$

$$\frac{1}{4} \rightarrow$$

$$\begin{array}{l} N_c \gg 1 \\ N_f \gg 1 \\ \lambda_{11} \gg 1 \end{array}$$



$$r_H \ll r_s \ll r_{\text{ED}}$$

$$\epsilon_x \left| \log \frac{r_H}{r_x} \right| \ll 1 \rightarrow \frac{r_H}{r_x} \gg e^{-1/\epsilon_x}$$

$$e^{-1/\epsilon_x} \ll \frac{r_H}{r_x} \ll \epsilon_x \ll 1$$

$$\begin{array}{l} N_c \gg 1 \\ N_f \gg 1 \\ \lambda_{11} \gg 1 \end{array}$$

$$\hat{q} \rightarrow q \cdot \hat{q}_{\text{eff}} (1 + \# \epsilon_{11})$$

$$r_H \ll r_s \ll r_{\text{L.D.}}$$

$$\epsilon_x \left| \log \frac{r_H}{r_x} \right| \ll 1 \rightarrow \frac{r_H}{r_x} \gg e^{-1/\epsilon_x}$$

$$e^{-1/\epsilon_x} \ll \frac{r_H}{r_x} \ll \epsilon_x \ll 1$$

$$\hat{q} \rightarrow q \cdot \hat{q}_{\text{vir}} (1 + \# \epsilon_H)$$

$$\hat{q} \sim 5-15 \frac{\text{GeV}^2}{f_{\text{vir}}}$$

$$\begin{array}{l} N_c \gg 1 \\ N_f \gg 1 \\ \lambda_{11} \gg 1 \end{array}$$

$$r_H \ll r_s \ll r_{\text{LD}}$$

$$\epsilon_x \left| \log \frac{r_H}{r_x} \right| \ll 1 \rightarrow \frac{r_H}{r_x} \gg e^{-1/\epsilon_x}$$

$$e^{-1/\epsilon_x} \ll \frac{r_H}{r_x} \ll \epsilon_x \ll 1$$

$$\begin{array}{l} N_c \gg 1 \\ N_f \gg 1 \\ \lambda_{11} \gg 1 \end{array}$$

$$\hat{q} \rightarrow q \cdot \hat{q}_{\text{eff}} (1 + \# \epsilon_{11})$$

$$\hat{q} \sim 5-15 \frac{\text{GeV}^2}{\text{fm}}$$

$$\hat{q} \sim 4 \frac{\text{GeV}}{\text{fm}}$$

$$r_h \ll r_s \ll r_{ph}$$

$$\epsilon_x \left| \log \frac{r_h}{r_x} \right| \ll 1 \rightarrow \frac{r_h}{r_x} \gg e^{-1/\epsilon_x}$$

$$e^{-1/\epsilon_x} \ll \frac{r_h}{r_x} \ll \epsilon_x \ll 1$$

$$\begin{array}{l} N_c \gg 1 \\ N_f \gg 1 \\ \lambda_{11} \gg 1 \end{array}$$

$$\hat{q} \rightarrow q \cdot \hat{q}_{ul} (1 + \# \epsilon_{11})$$

$$\hat{q} \sim 5-15 \text{ GeV}^2$$

$$\hat{q} \sim 4 \frac{eV}{fm}$$

$$r_H \ll r_s \ll r_{\text{curv}}$$

$$\epsilon_x \left| \log \frac{r_H}{r_x} \right| \ll 1 \rightarrow \frac{r_H}{r_x} \gg e^{-1/\epsilon_x}$$

$$e^{-1/\epsilon_x} \ll \frac{r_H}{r_x} \ll \epsilon_x \ll 1$$

$$\boxed{\begin{array}{l} N_c \gg 1 \\ N_f \gg 1 \\ \lambda_{11} \gg 1 \end{array}}$$

$$\hat{q} \rightarrow q \cdot \hat{q}_{\text{vir}} (1 + \# \epsilon_{11})$$

$$\hat{q} \sim 5-15 \frac{60 \text{ eV}^2}{f_{\text{vir}}}$$

$$\hat{q} \sim 4 \frac{60 \text{ eV}^2}{f_{\text{vir}}}$$

$$\sim 5.2$$

$$l_H \ll r_s \ll r_{\text{vir}}$$

$$\epsilon_x \left| \log \frac{r_H}{r_x} \right| \ll 1 \rightarrow \frac{r_H}{r_x} \gg e^{-1/\epsilon_x}$$

$$e^{-1/\epsilon_x} \ll \frac{r_H}{r_x} \ll \epsilon_x \ll 1$$

$$\hat{q} \rightarrow q \cdot \hat{q}_{\text{vir}} (1 + \epsilon_H)$$

$$\hat{q} \sim 5-15 \frac{(\text{GeV})^2}{f_{\text{vir}}}$$

$$\hat{q} \sim 4 \frac{(\text{GeV})^2}{f_{\text{vir}}}$$

$$\sim 5.2$$

$$\begin{array}{l} N_c \gg 1 \\ N_f \gg 1 \\ \lambda_H \gg 1 \end{array}$$