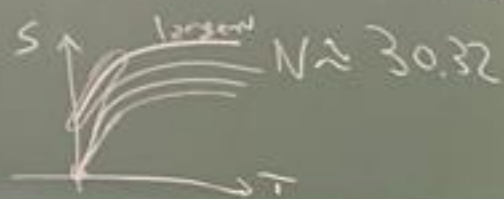


RG flows of SYK

- SYK \rightarrow N Majorana fermions
 $\{\psi_i, \psi_j\} = \delta_{ij}$

\rightarrow Finite N $H_{\text{SYK}}^q = (i)^{q/2} \sum_{j_1, \dots, j_q} J_{j_1, \dots, j_q} \psi_{j_1} \dots \psi_{j_q}$

$\langle J \rangle = 0$
 $\langle J^2 \rangle = \gamma^2$
 dimension of $\mathcal{H} = 2^{N/2}$
 $\frac{\gamma^2}{N^{q-1}}$



* large- N G, Σ action
 $G \rightarrow \Delta = \frac{1}{\gamma}$
 $G = \frac{1}{N} \sum \langle T \psi_i(\tau) \psi_i(0) \rangle$

FFT algorithm $\Rightarrow \begin{cases} G = (\partial_\tau - \Sigma)^{-1} \\ \Sigma = \gamma^2 G^{q-1} + S^2 \gamma^2 G^{q-1} \end{cases}$

* large q $G = (1 + \frac{g(\tau)}{\gamma} + \dots)$
 $\partial_\tau^2 g(\tau) = \gamma^2 e^{g(\tau)} + n S^2 \gamma^2 e^{g(\tau)}$

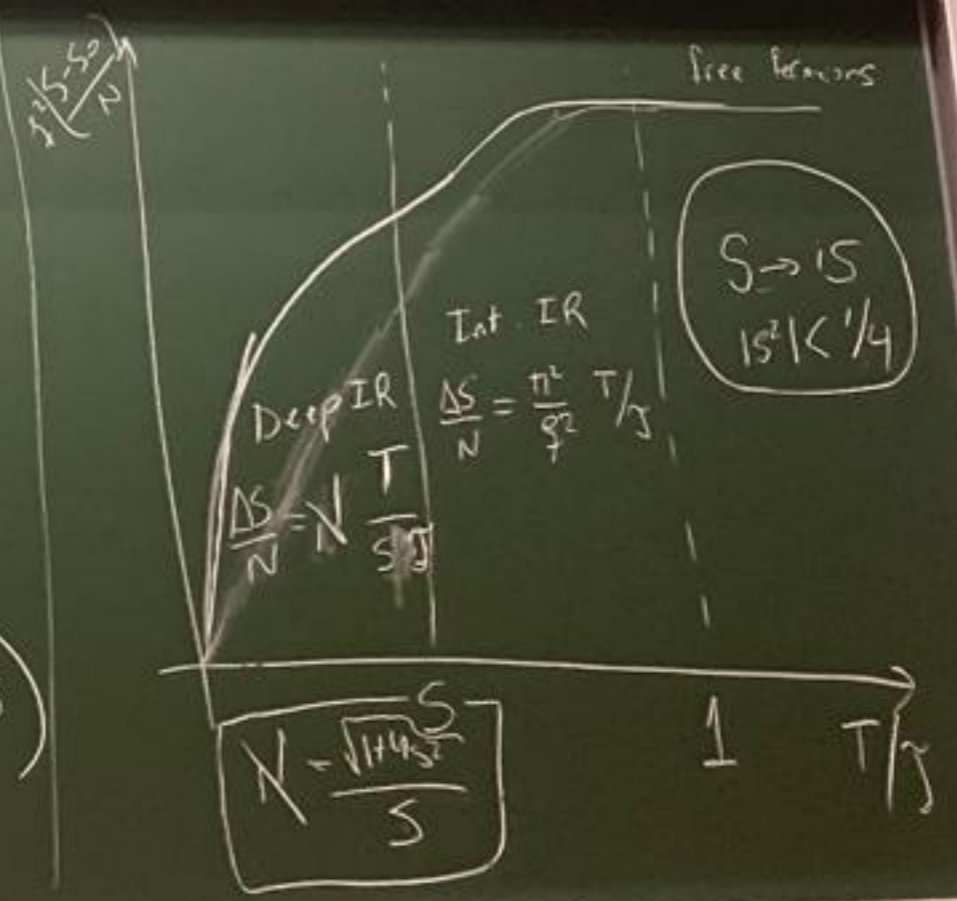
$n=2 \rightarrow$ Analytic solts

* $\frac{S(T)}{N} = S_0 + C \frac{T}{\gamma} + \dots$

* $\psi_i \partial_\tau \psi_i \rightarrow$ irrelevant

* $H = H_{\text{SYK}}^{(q)} + S H_{\text{SYK}}^{(q)}$
 (relevant)

$q > \frac{2}{\gamma} \Rightarrow$ Two dimensionless couplings $\rightarrow (\frac{T}{\gamma}, S)$
 $\frac{q}{\gamma} = n$



* IBVP in GR is not well posed w/ Dirichlet or Neumann b.c [An, Anderson, 21]

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R + (\Lambda g_{\mu\nu}) = 0$$



* Are there other b.c?
A: (conjecture) Conformal bdy conditions $\{[h], K\}$

* d=2

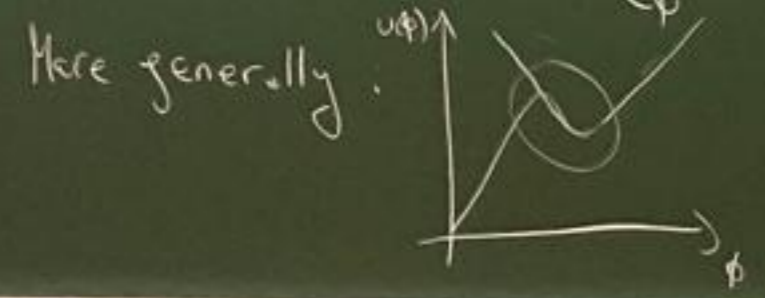
- Plan.
- ① Dilaton-gravity theories
 - ② Microscopic RG flows of SYK
 - ③ Discussion

① $I_E = -\frac{1}{16\pi G_N} \int_M \sqrt{g} (\phi R + U(\phi)) + \int_{\partial M} \sqrt{h} \phi_0 (K - 1)$

$$\frac{\delta}{\delta \phi} \quad \boxed{R = -U'(\phi)}$$

Examples: JT gravity, $U(\phi) = 2\phi$

\downarrow AdS₂
dS JT, $U(\phi) = -2\phi$



* Thermodynamics

$$T = \frac{U(\phi_h)}{4\pi}, \quad S = S_0 + \frac{\phi_h}{8\pi G_N}$$

$$\xrightarrow{\text{JT}} \quad T = \frac{\phi}{2\pi} \rightarrow \boxed{S - S_0 \propto T}$$

$$S - S_0(T) \rightarrow \boxed{T(S - S_0) = U(\phi_h)}$$

* Matrix Model [Seib, Shenker, Stanford]

↳ Witten, Maxfield, Taroni

* RG flows of SYK

STATIC PATCH Holography & RG Flows of SYK

in collaboration w/
D Anninos & D Hofman
S Chapman, B Muhlmann,
D Vegh, S Theorey,
C Manceat, E Harris,

* Q: How do we do holography in the static patch of dS?

↳ ① Stretched horizon

② Worldline observer

↳ Static patch solipsism '12

↳ Algebraic approach ('22, '23)

gravity + observer \rightarrow Type III \rightarrow Type II₁

* Timelike boundaries

* Thermodynamics in dS

① Wald

② Gibbons-Hawking

③ York \rightarrow add some artificial timelike bdy & describe thermo from bdy data fixed at this bdy.

$\{B, A\} \rightarrow$ Dirichlet data

* Static patch

[Hegner, '80's, Wang, Huzar, 'd]

* JT gravity (dS)

['21]

* In 3d

* In 4d [Ben-heshkoni, Jacobson '22]