

A new universal charge for conformal interfaces

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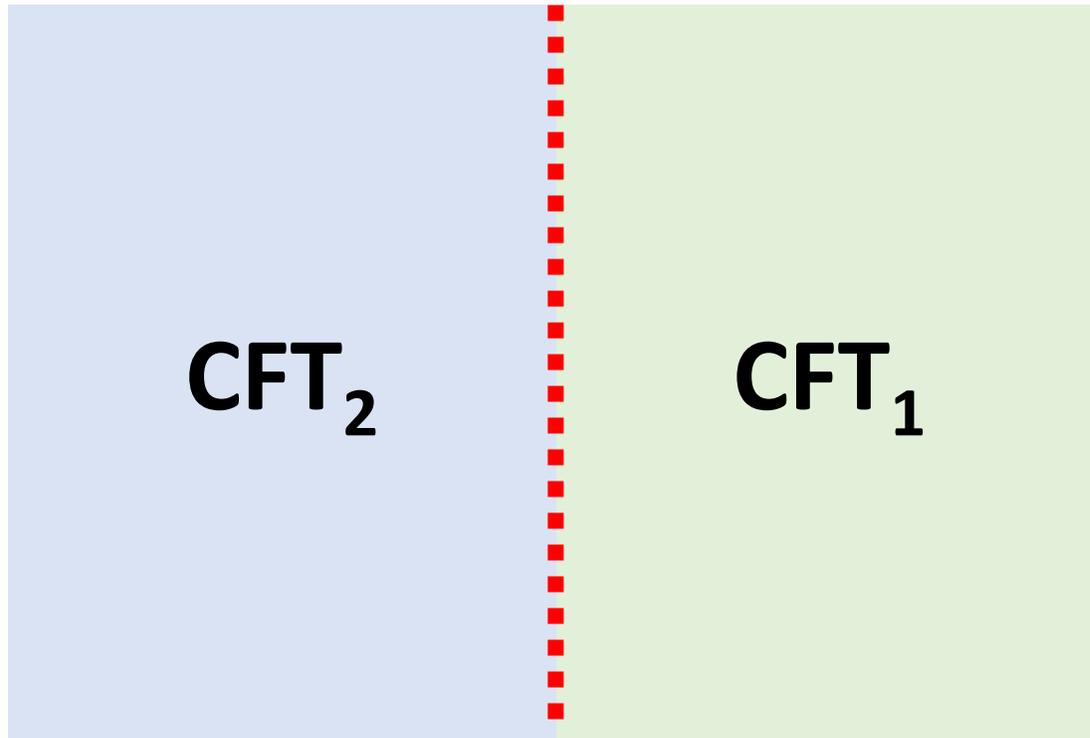
YITP Workshop “Symmetry & Interfaces”, March xx, 2026

work with Mianqi Wang (UT → IPMU)

Why 2d Interface Conformal Field Theories

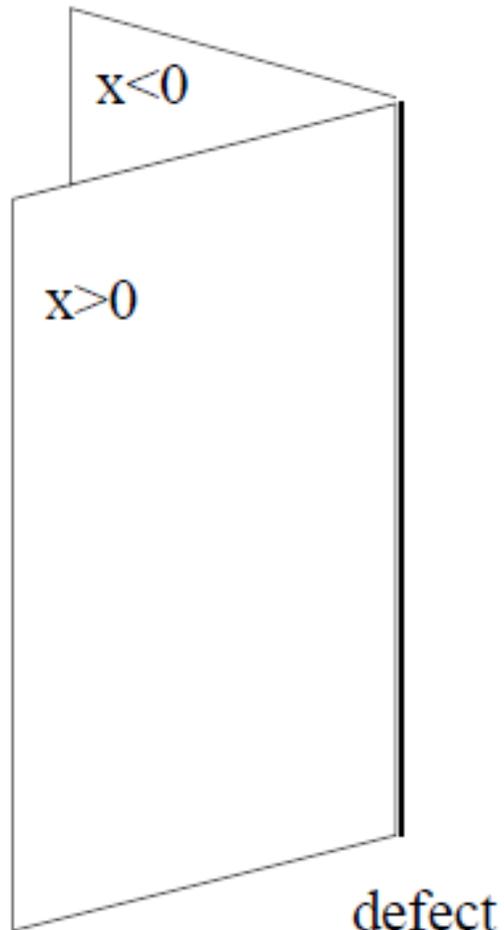
- 2d conformal interfaces are the easiest interfaces with actual dynamics; we should understand them
- Interfaces may help understand conformal manifolds
- Characterized by a few universal quantities: c_{eff} , c_{LR} , g
- Rapid progress on these in recent years

The setting



- Generalization of BCFT
- Plethora of options
- BCFT special case (CFT_2 trivial)

ICFT = BCFT?



Folding trick suggests that an ICFT is really just a special kind of BCFT

$$\text{ICFT} = \text{B}(\text{CFT}_1 \times \text{CFT}_2)$$

But many quantities only natural when viewed as ICFT

ICFT \neq BCFT!

There are novel questions we can ask in an ICFT that don't look natural in the folded picture, but are extremely natural for an ICFT.

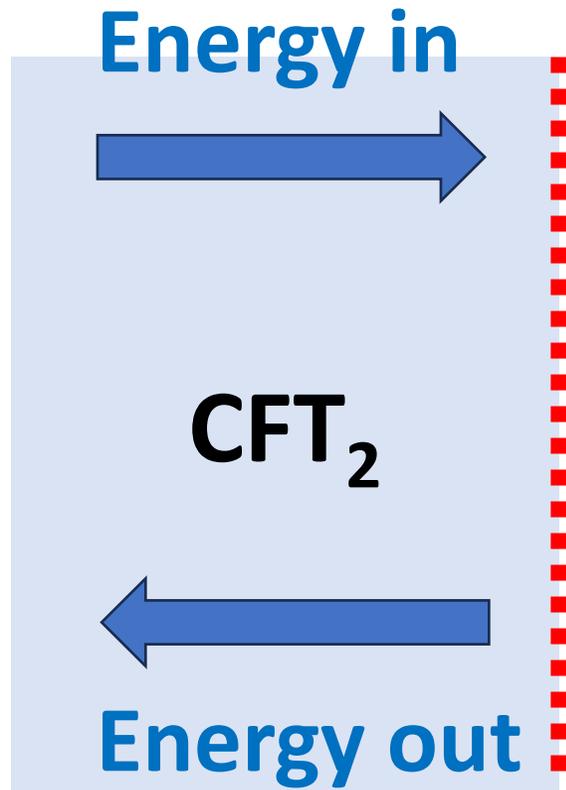
- Energy transport: c_{LR}
- Information transport: c_{eff}
- Dissipation transport: c_{relax}

**much studied in
recent years**

← our focus today

C_{LR}

Energy transport in BCFT vs ICFT

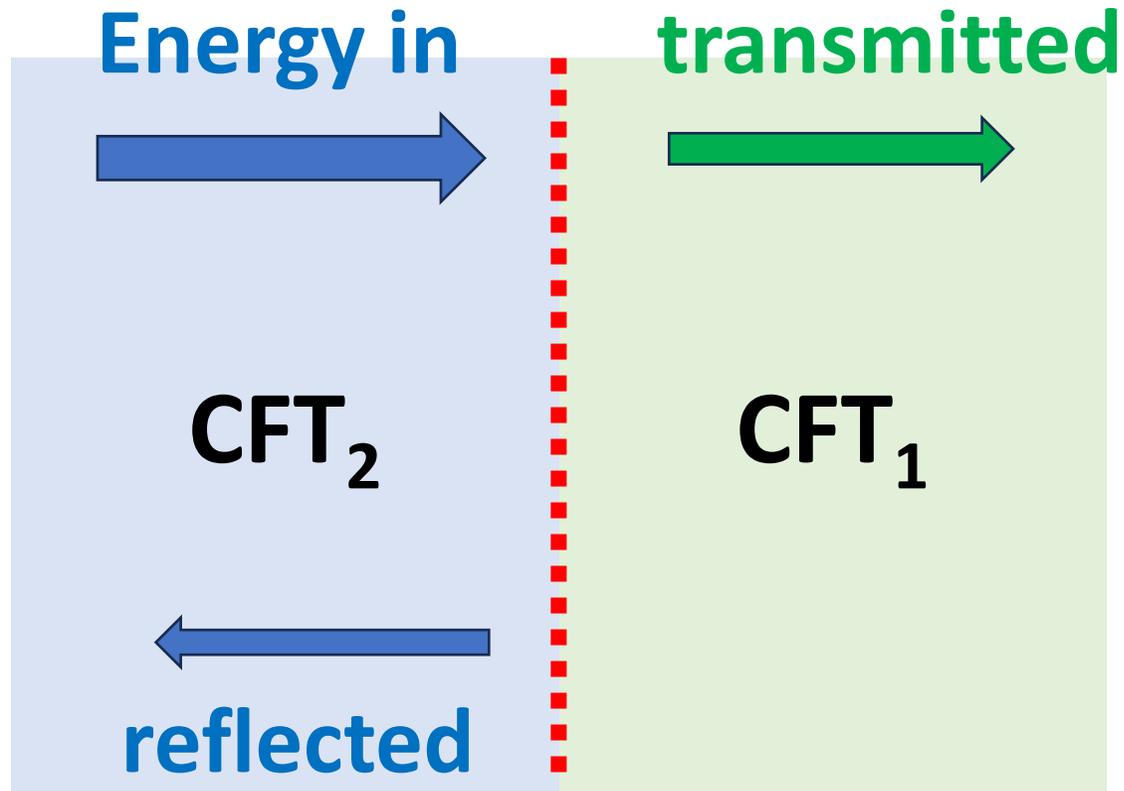


Boundary/interface breaks translations. No more conserved momentum. But energy conserved

Energy in = Energy out

$$R = 1 \quad (\text{reflection coefficient})$$

Energy Transport in BCFT vs ICFT



In ICFT non-trivial
reflection/transmission

$$R + T = 1$$

Energy transport and central charges

Reflection/transmission universally determined by one number:

(Quella, Runkel, Watts; Meineri, Penedones, Rousset)

$$\langle T_L(z_1)T_R(z_2) \rangle_I = \frac{c_{LR}/2}{(z_1 - z_2)^4}$$

central charge mixing left and right

$$\mathcal{J}_L = \frac{c_{LR}}{c_2} \quad \mathcal{J}_R = \frac{c_{LR}}{c_1}$$

in general different from left to right vs from right to left

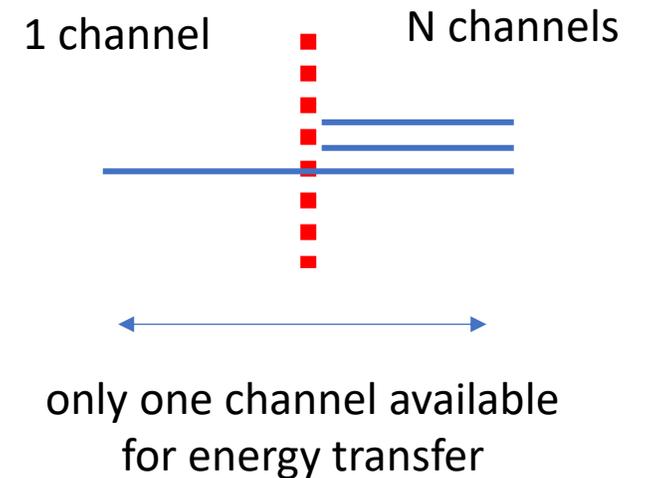
Bounds on transmission:

$$0 \leq c_{LR} \leq \min(c_1, c_2)$$

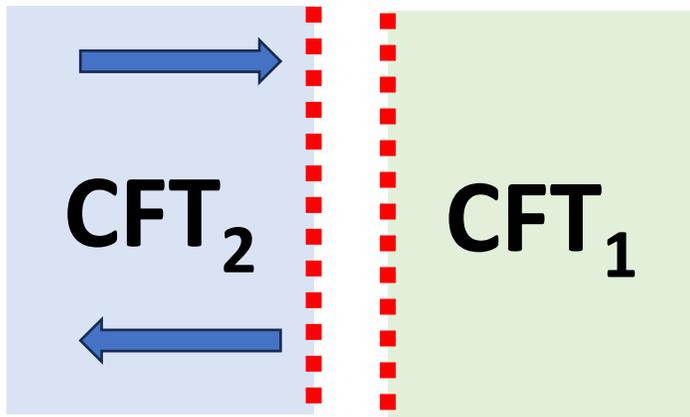
(Meineri, Penedones, Rousset)

$$T_{small\ c \rightarrow large\ c} \leq 1$$

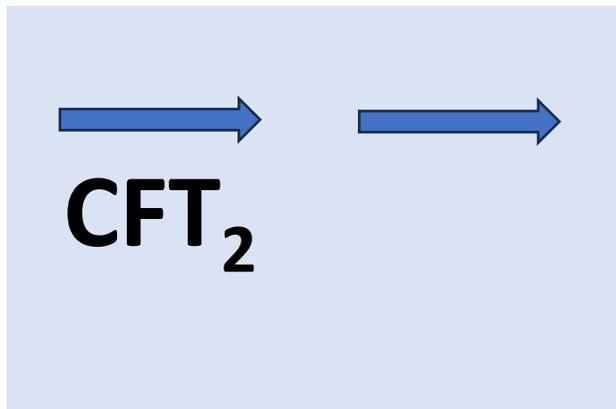
$$T_{large\ c \rightarrow small\ c} \leq \frac{c_{small}}{c_{large}}$$



2 extreme cases:



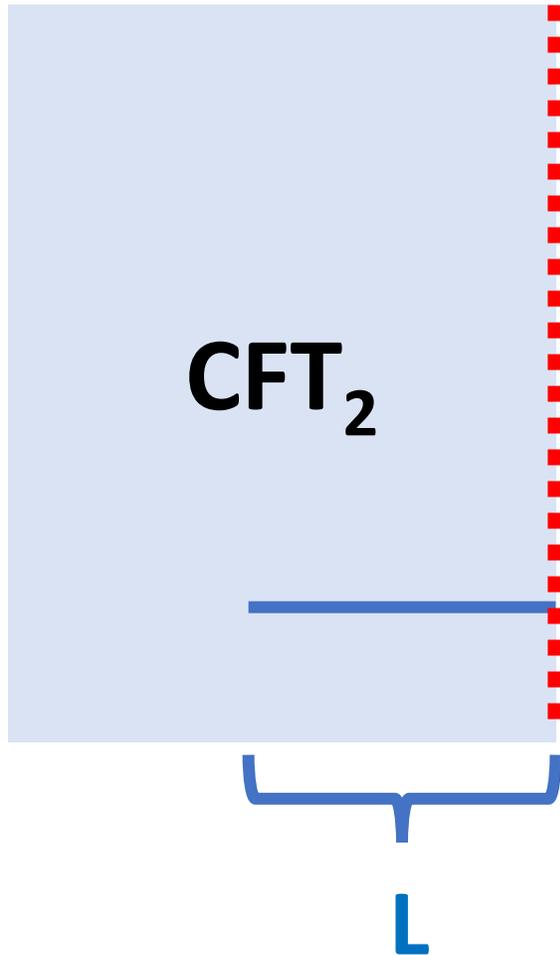
T=0



T=1

C_{eff}

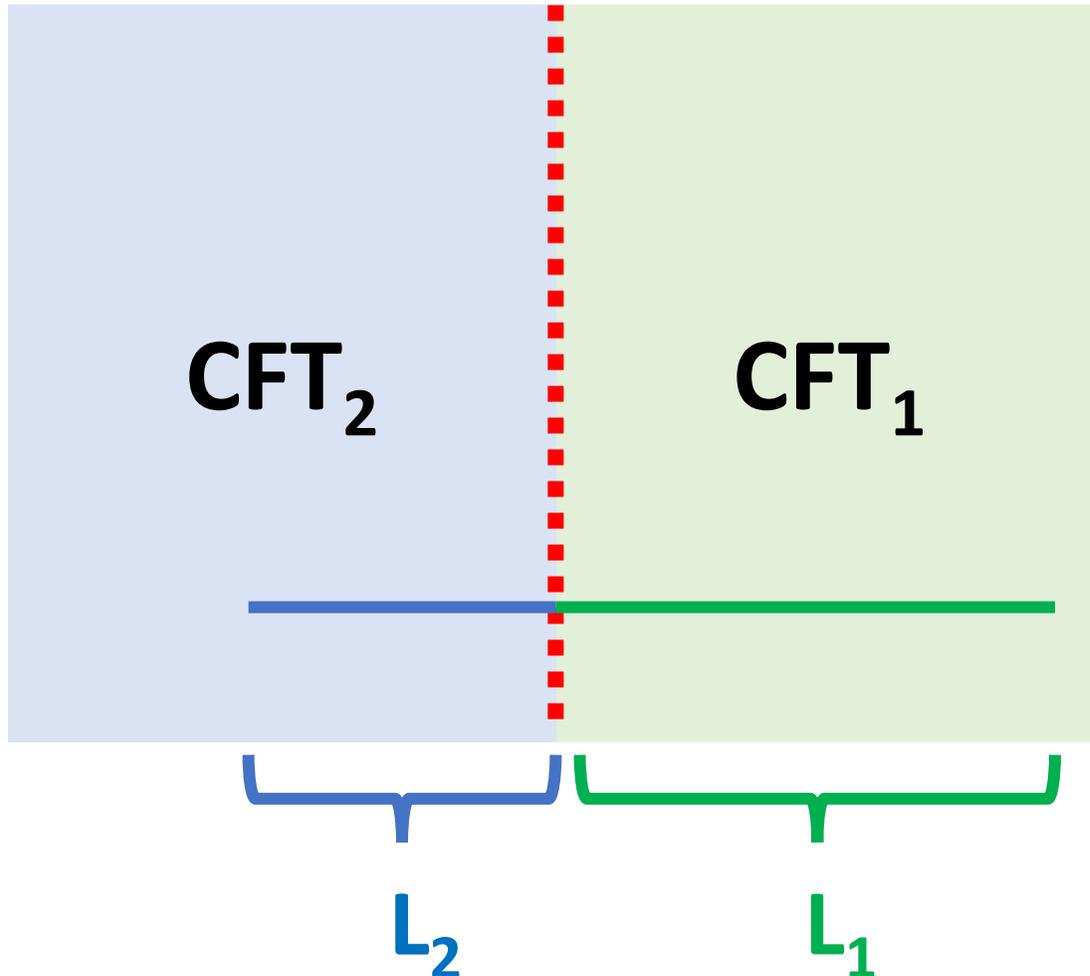
EE in BCFT vs ICFT



$$S_{EE} = \frac{c_2}{6} \log \frac{L}{a} + \log(g)$$

- Universal result
- Log divergent term set by bulk central charge
- g measures boundary DOFs

EE in BCFT vs ICFT

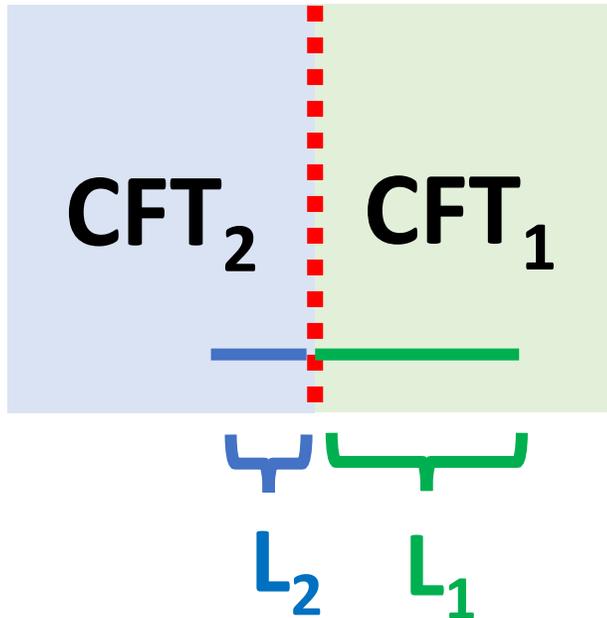


Now we have options!

Only if $L_1=L_2$ do we fold to “standard” BCFT situation

Choices, choices

(Luo, Sun, AK; Afxonidis, Carreno Bolla, Hoyos, AK)



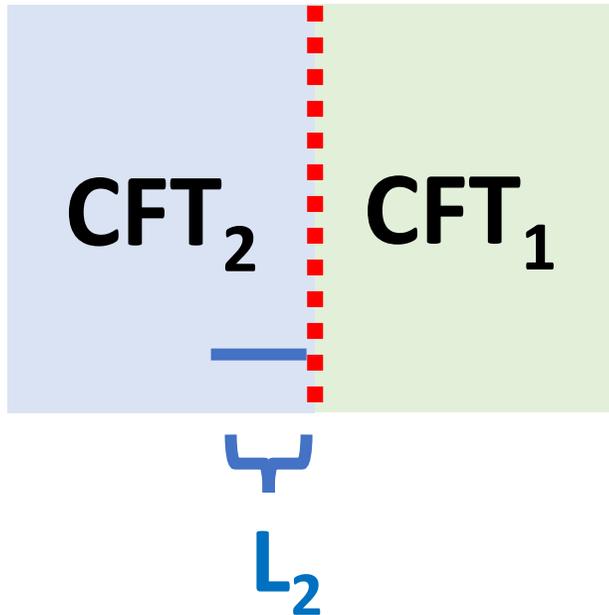
Can contemplate various scenarios....

Generic case: both L_1 and L_2 finite, not necessarily equal ($L=L_1+L_2$)

$$S_{EE} = \frac{c_1 + c_2}{6} \log \frac{L}{a} + \log \left(g \left(\frac{L_1}{L_2} \right) \right)$$

- log coefficients add
- g depends on shape
- standard BCFT result contained as special case: $g=g(1)$
- **Universal log divergence in $g(0)$**

Choices, choices



Special case: (say) $L_1=0$, L_2 finite

Log term no longer universal!

(Peschel; Luo, Sun, AK; Kusuki, Ooguri, Sun, Wang, AK)

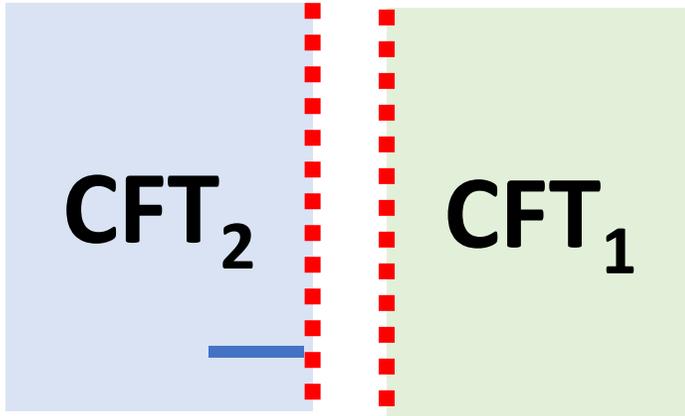
(divergence in g “makes it” to log term)

$$S_{EE} = \frac{c_{eff} + c_2}{6} \log \frac{L_2}{a} + \log(g')$$

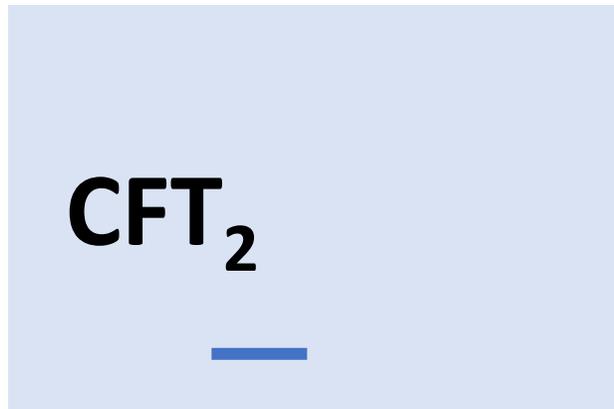
“effective central charge”

depends on details of boundary conditions!

2 extreme cases:



- Two decoupled BCFTs.
- $c_{\text{eff}} = 0$
- S_{EE} just standard BCFT answer in CFT_2



- trivial interface (“no braner”)
- just an ordinary CFT
- $c_{\text{eff}} = c_2$

Universal Bounds

$$0 \leq c_{LR} \leq c_{eff} \leq \min(c_1, c_2)$$

(Kusuki, Ooguri, Sun, Wang, AK)

Review summary:

Besides the bulk quantities c_1 and c_2 , interface CFTs are universally governed by two more central charges:

- c_{LR} (Energy Transport)
- c_{eff} (Information Transport)

C_{relax}

Interfaces in open quantum systems

- A lot of recent interest in open quantum systems
- Old view: dissipation destroys coherence, it's an obstacle to overcome
- Recently come to appreciate dissipation as a resource: novel quantum phenomena that rely on the presence of dissipation
- Framework: **Lindblad equation**

Lindblad – need to know basis

- Dissipation arises from coupling to an environment/bath
- Assume bath is Markovian: energy dissipated into the bath does not change the state of the bath and so the dissipative dynamics **stays the same** over time
- Lindblad: integrate out the bath introducing effective Jump operators into the “Hamiltonian”
- **Hermitian Hamiltonian replaced by non-Hermitian Lindbladian**

Relaxation to steady state

- Lindbladian allows **complex eigenvalues**
- Generic initial conditions relax to steady state
- **The smallest imaginary part controls the relaxation rate**
- **QUESTION: How do interfaces affect the relaxation rate?**

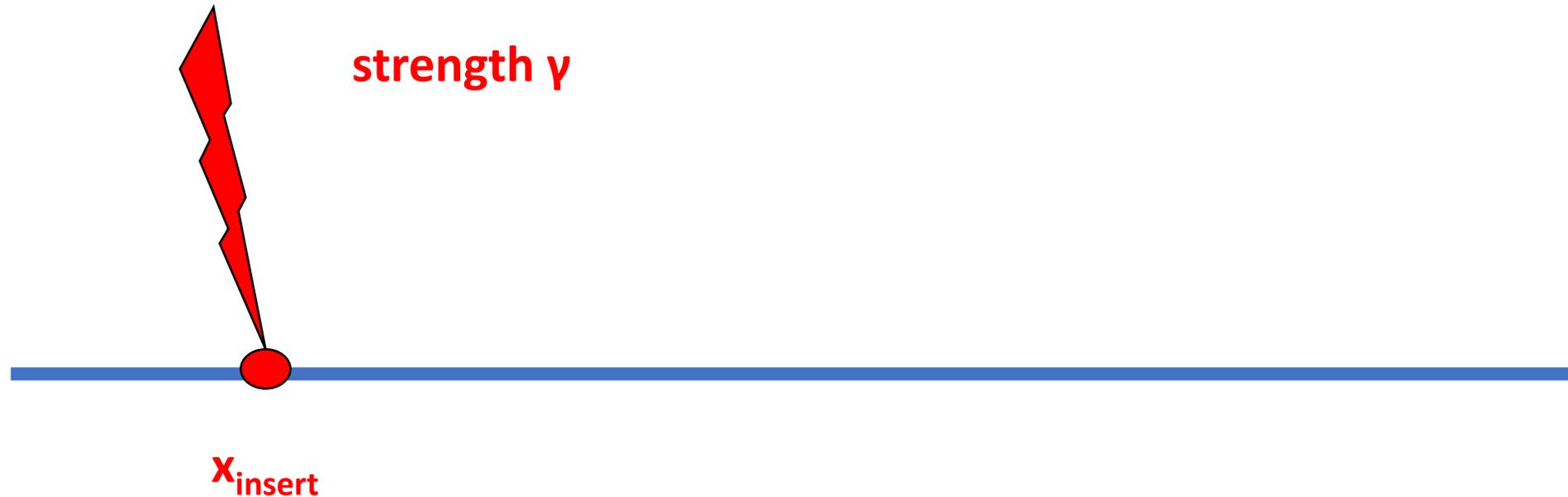
Interfaces in Fermion Chains with Dissipation

(Barak, Tan, Wen)

Free fermions hopping on a lattice
leading to free fermion $c=1$ CFT

Interfaces in Fermion Chains with Dissipation

(Barak, Tan, Wen)

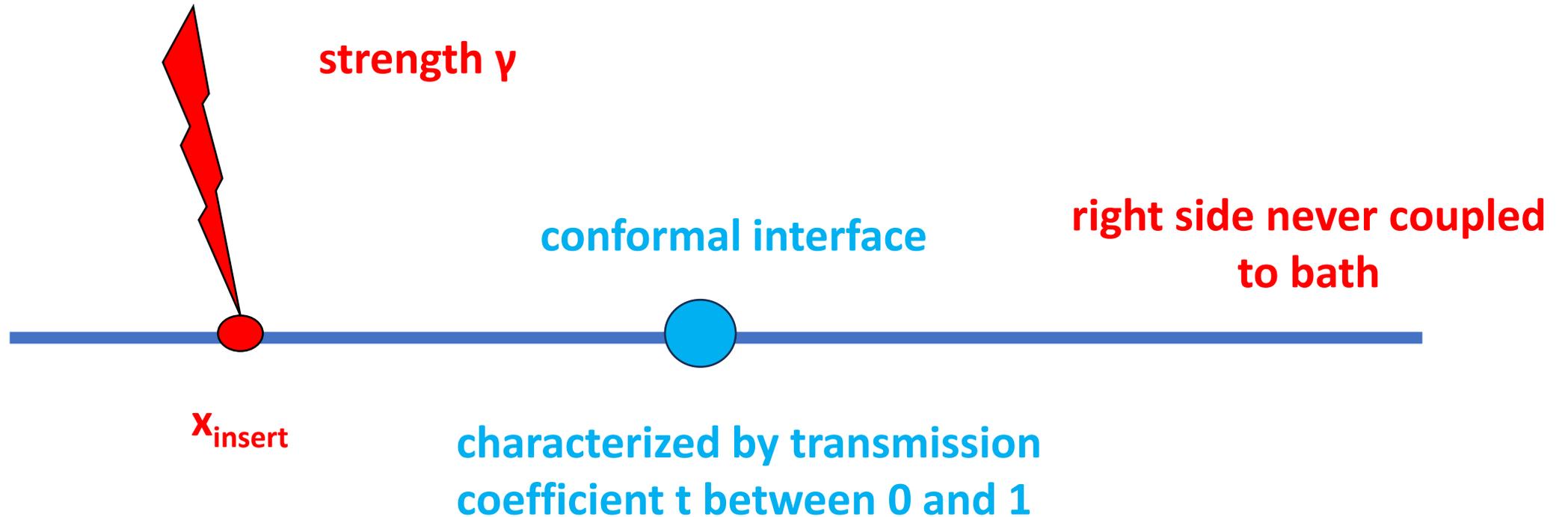


Local coupling to bath gives rise to dissipation rate $g^{-1}(\gamma, x_i)$

**Insert local coupling to external bath
(local jump operator in Lindbladian)**

Interfaces in Fermion Chains with Dissipation

(Barak, Tan, Wen)



Presence of interfaces slows
down dissipation rate $g^{-1}(\gamma, x_i, t)$

Interfaces in Fermion Chains with Dissipation

(Barak, Tan, Wen)

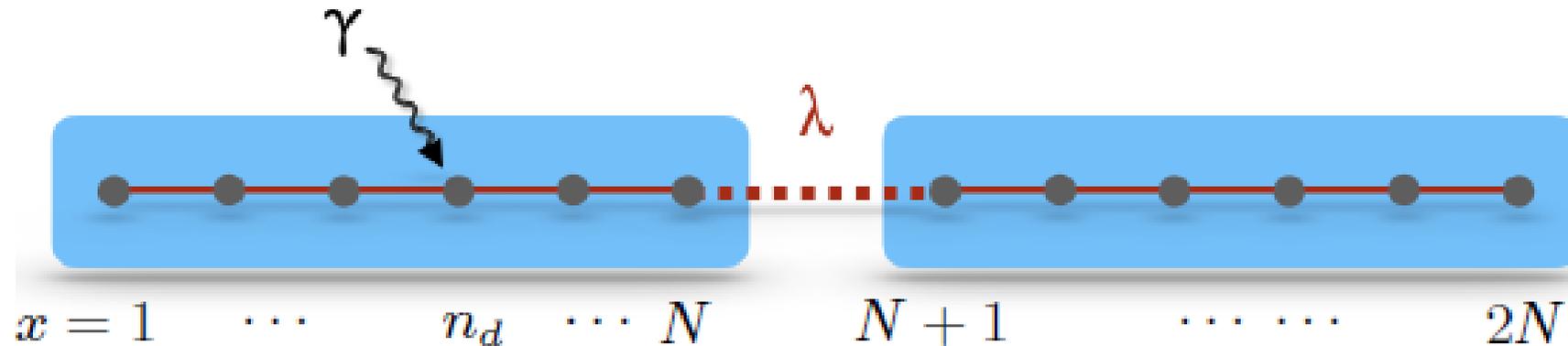
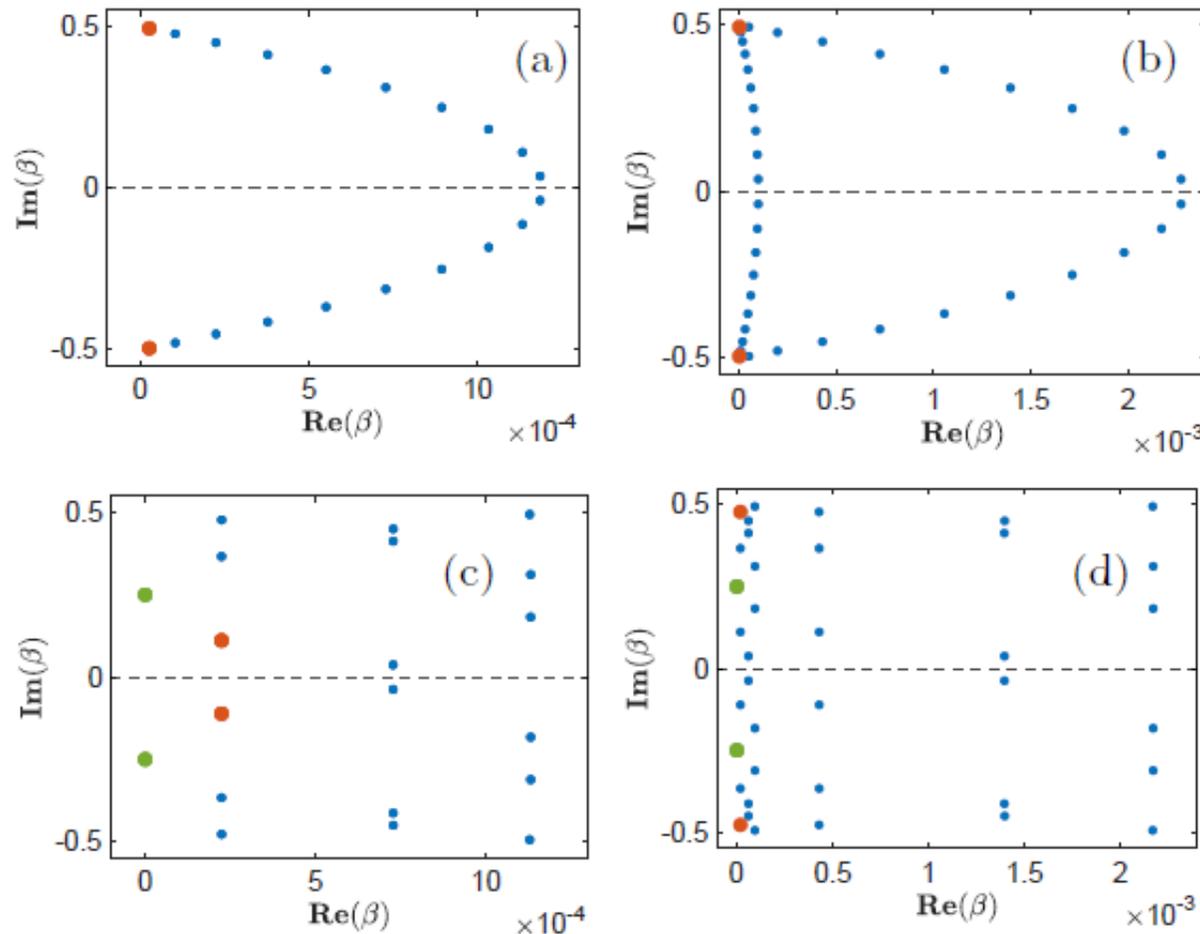


FIG. 2. Two free-fermion chains of size N are connected via a conformal interface characterized by a parameter λ . A local dissipation of strength γ is introduced at site $n_d \in [1, N]$ on the left chain. The total system size is $L = 2N$.

Spectra depend strongly on all parameters

(Barak, Tan, Wen)



Warning: role of real and imaginary part flipped

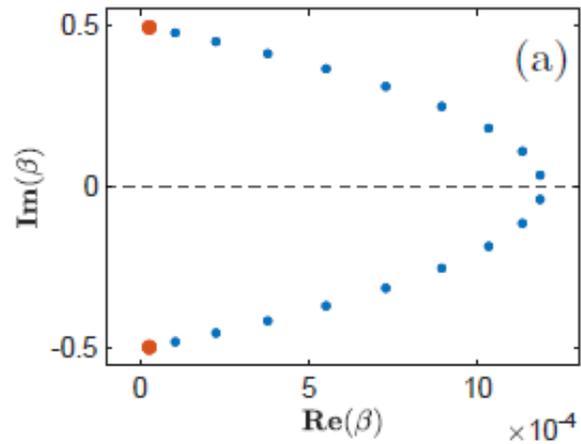
Red points give the relaxation rate (nearest but not on axis)

Green points are purely oscillatory

Spectra depend strongly on all parameters

(Barak, Tan, Wen)

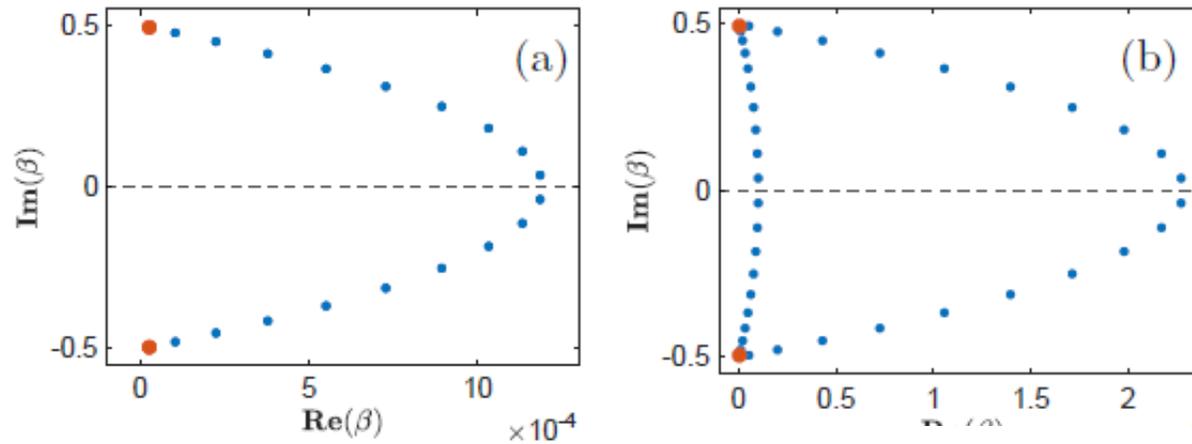
No interface



Red points give the relaxation rate (nearest but not on axis)

Spectra depend strongly on all parameters

(Barak, Tan, Wen)



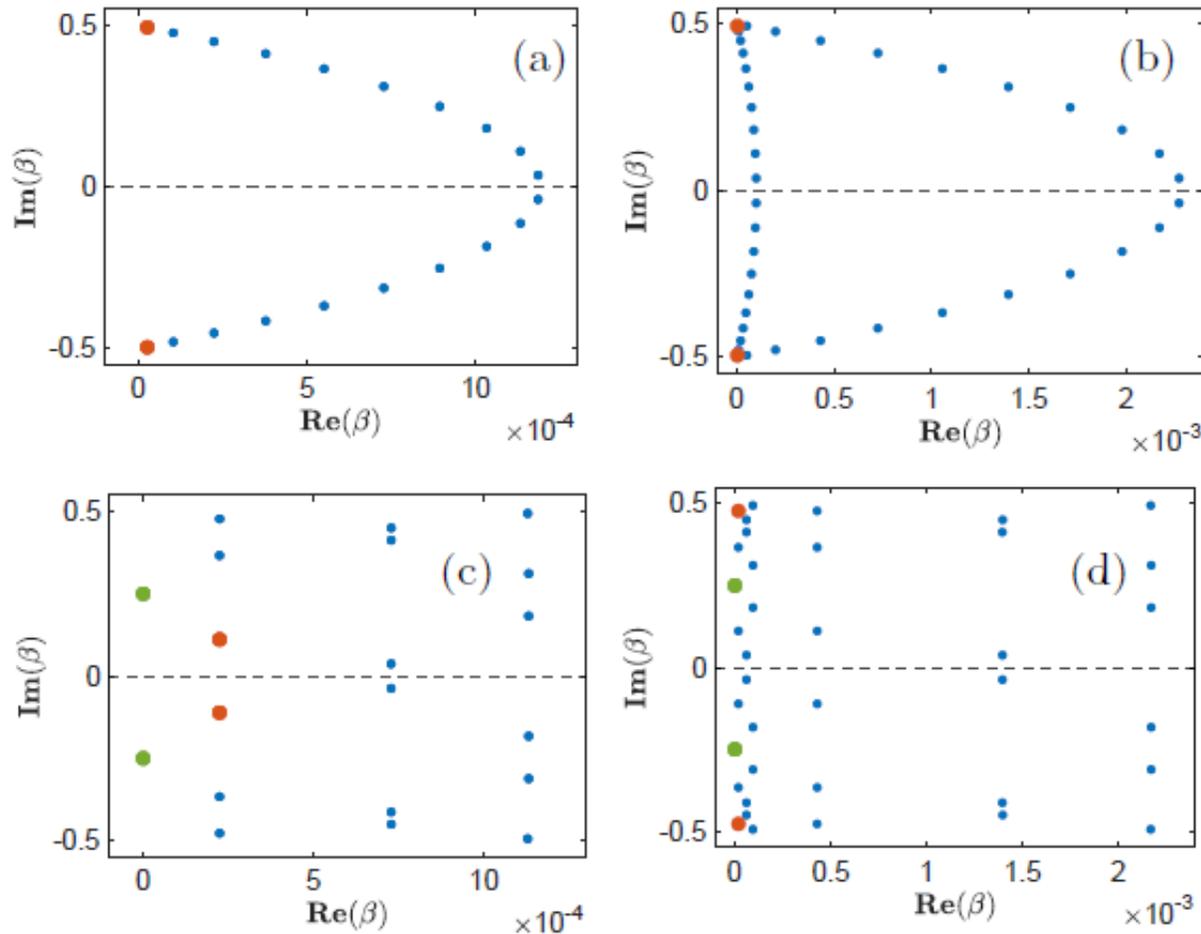
**semi-transparent
interface**

**source of dissipation
far from interface**

“left dissipation” similar to before
“right dissipation” much slower

Spectra depend strongly on all parameters

(Barak, Tan, Wen)



dissipation near interface; modes change dramatically

A universal quantity emerges

(Barak, Tan, Wen)

$$c_{relax} = \frac{g(\gamma, x_i, t)}{g(\gamma, x_i, 1)} c$$

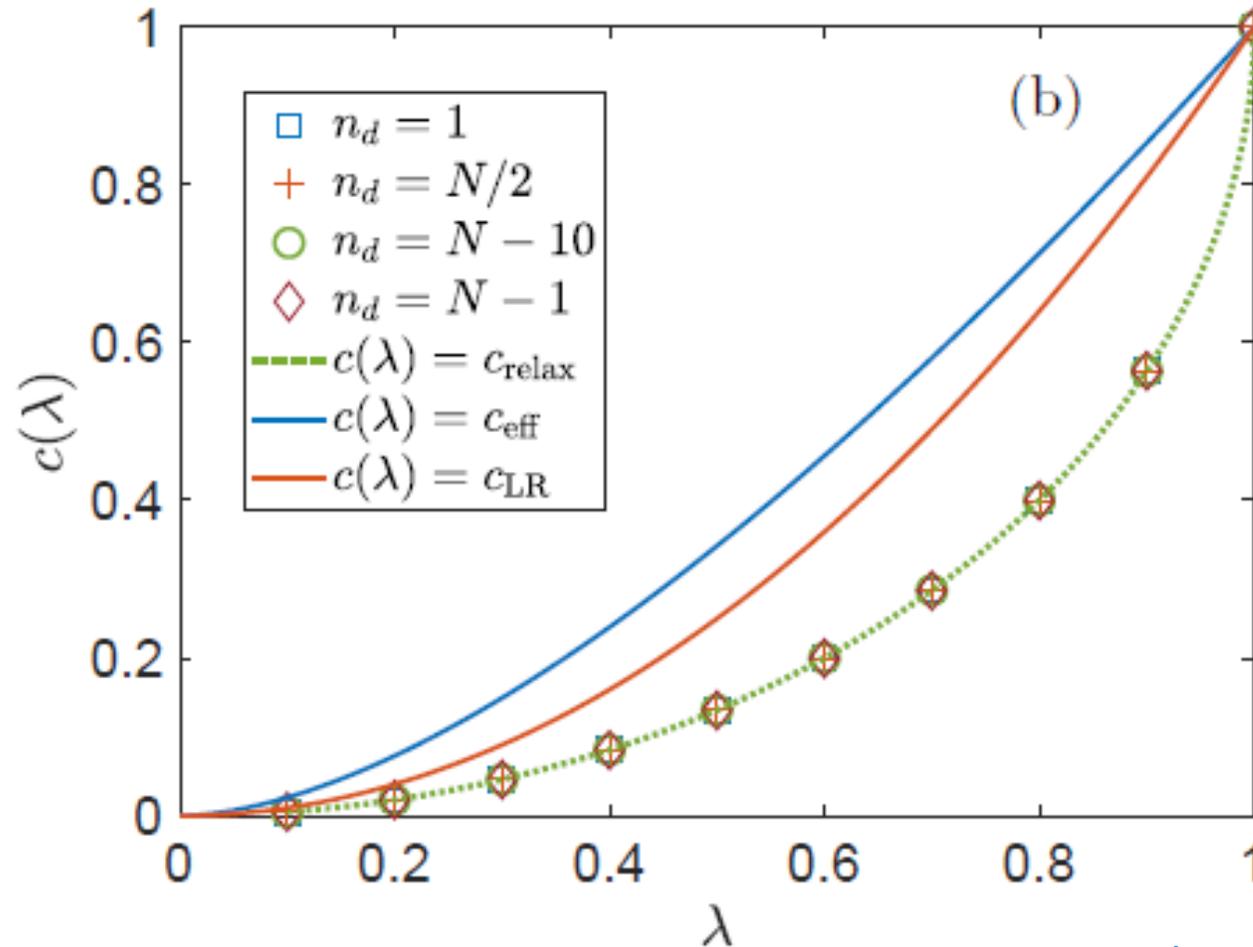
 c=1 for free fermion

The **ratio** of relaxation rate **with and without interface** turns out to be **insensitive to insertion point and dissipation strength!!!**

Property of interface. “Transmission coefficient for dissipation”

Energy, Information and Dissipation?

$$0 \leq c_{\text{relax}} \leq c_{\text{LR}} \leq c_{\text{eff}} \leq c$$



$$\frac{c_{\text{relax}}}{c} := \frac{g(\lambda)}{g(\lambda=1)} \approx 1 - \sqrt{1 - \lambda^2}$$

\uparrow
perturbative result for weak
dissipation

Beyond free fermions

This was all for free fermions.

Based on numerics and perturbation theory (valid for small dissipation strength)

Can this universality be found also in other ICFTs?

Holography?

Open Holography

Incorporating Lindblad directly into holography:
possible, but appears technically cumbersome

(Ishii, Takeda)

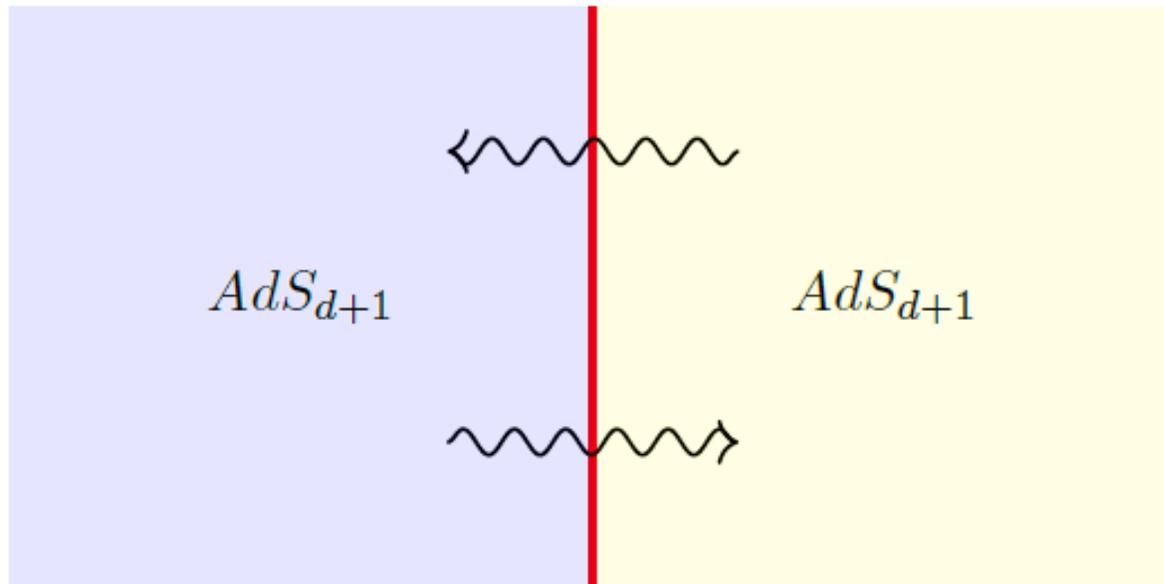
Our approach: describe **full dynamics of both system and bath**.
Feels like overkill, but gets the job done.
Since bath is large N theory, it effectively still is **Markovian**.

Double trace open holography

(Aharony, Clark, AK; Kiritsis - 2006)

(Geng - 2023; AK, Youssef – 2025)

Two AdS spaces coupled via boundary conditions:



$$\phi(z, t) = \alpha(t)z^{d-\Delta} + \beta(t)z^{\Delta} + \dots$$

Standard: $\alpha=0$ (on both sides)

Coupled:

$$\alpha_L(\vec{x}) = h(2\Delta - d)\beta_R(\vec{x})$$

$$\alpha_R(\vec{x}) = h(2\Delta - d)\beta_L(\vec{x})$$

Marginal Double Trace Open CFT:

(following Aharony, Berkooz,
Silverstein; Witten)

$$S_{CFT} \rightarrow S_{CFT} + h \int d^d x \mathcal{O}_L(x) \mathcal{O}_R(x)$$

Dimension Δ Dimension $d-\Delta$

Early Success: (Aharony, Clark, AK)

- 2 conserved stress tensors at $h=0$, only one after coupling
- 2 massless gravitons in the two decoupled AdS spaces
- One stress tensor gets anomalous dimension
- One graviton gets mass
- **Perfect match**

Marginal double trace

Note in the bulk we have the same mass scalar on both sides

Standard Quantization of left (Δ)

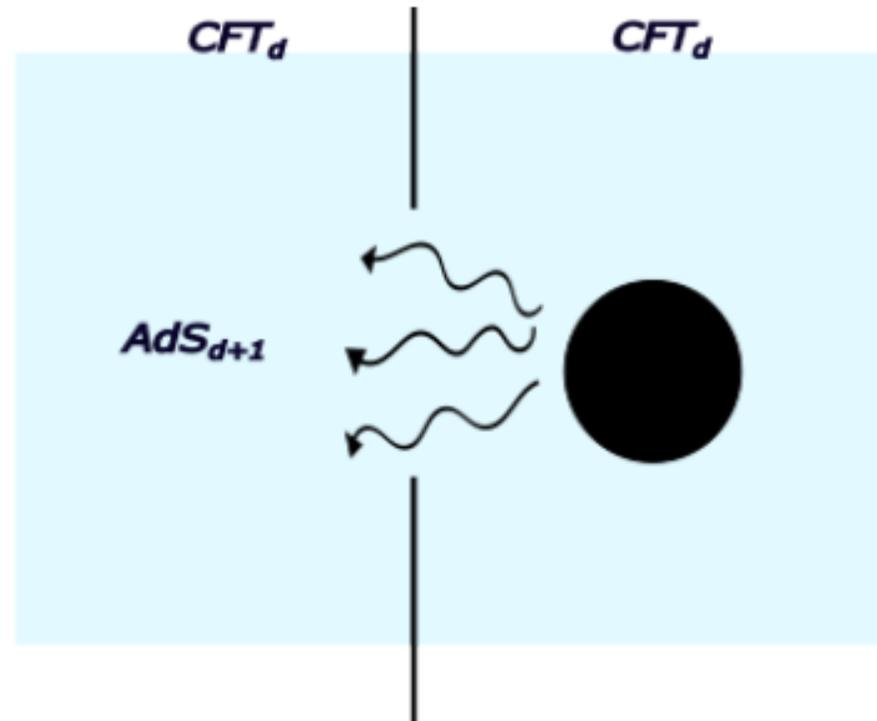
Alternate Quantization on right ($d-\Delta$)

(or vice versa)

Can be realized by starting with a top-down model with alternate quantization for at least one scalar and trigger RG to standard quantization on one side.

Repurposing DT for open holography

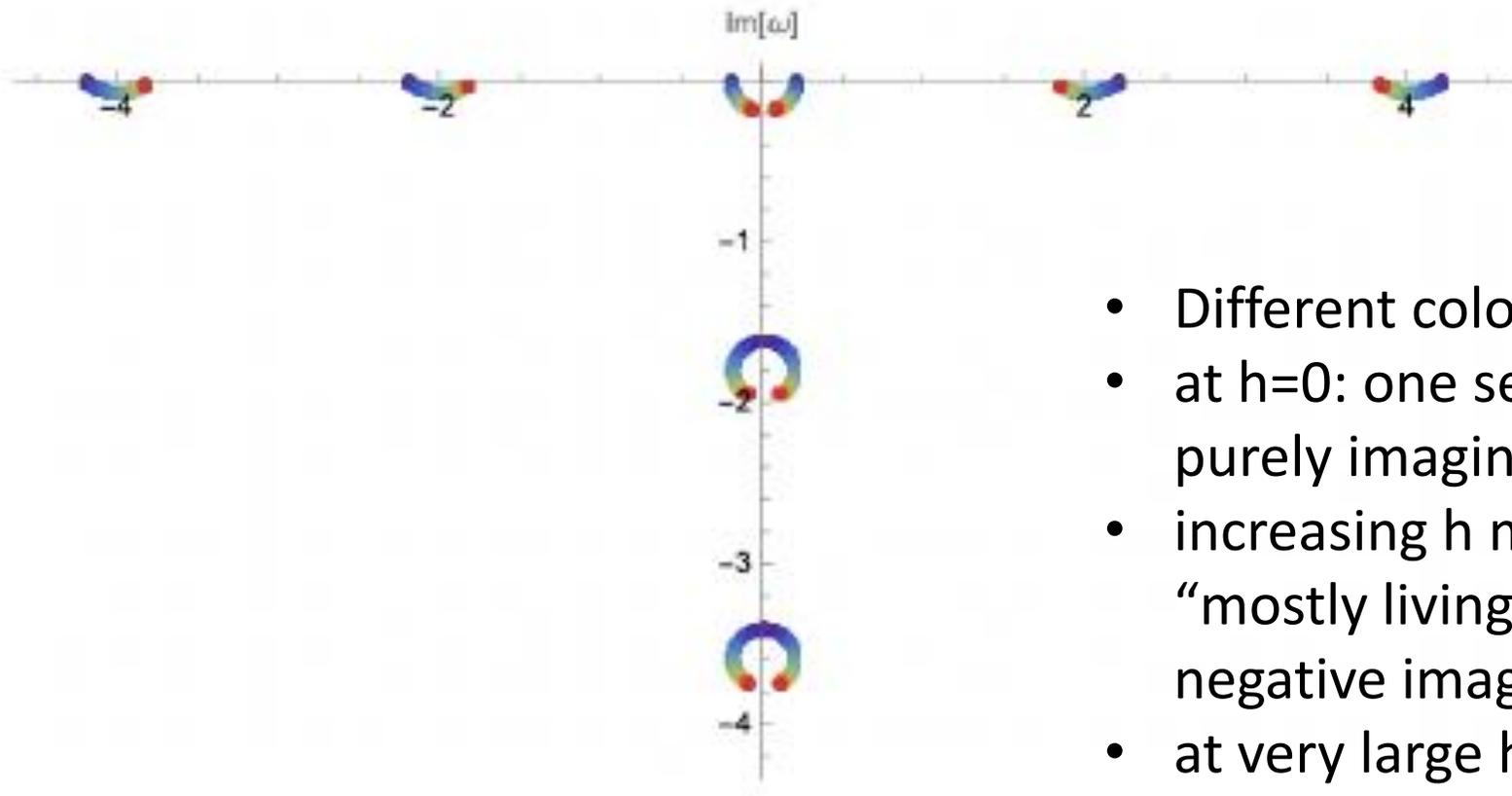
(Youssef, AK)



CFT: zero temperature
real spectrum at $\hbar=0$
pushed into complex plane by \hbar

Bath: finite T
complex spectrum
(quasi-normal modes)

Repurposing DT, (quasi) normal modes in 3d



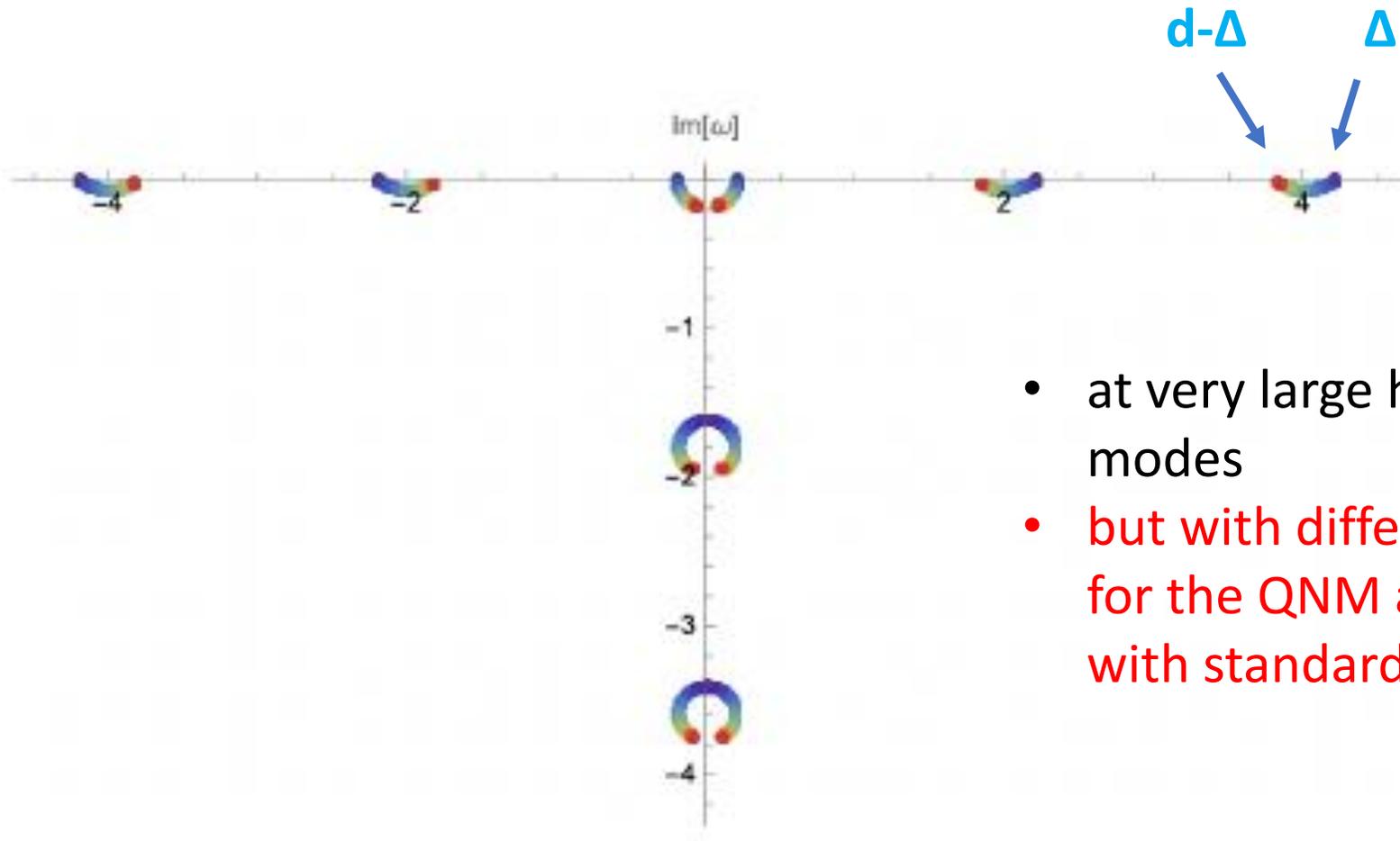
- Different colors = different h
- at $h=0$: one set of real (AdS) one set of purely imaginary (BTZ) modes
- increasing h mixes the modes. The modes “mostly living in AdS” get pushed to negative imaginary parts
- at very large h we return to 2 decoupled modes

Surprise: a strong weak dissipation duality

The holographic system exhibits an exact strong/weak coupling duality for \hbar !

Strong coupling with alternate/standard quantization gives weak coupling for standard/alternate quantization

Repurposing DT, (quasi) normal modes in 3d

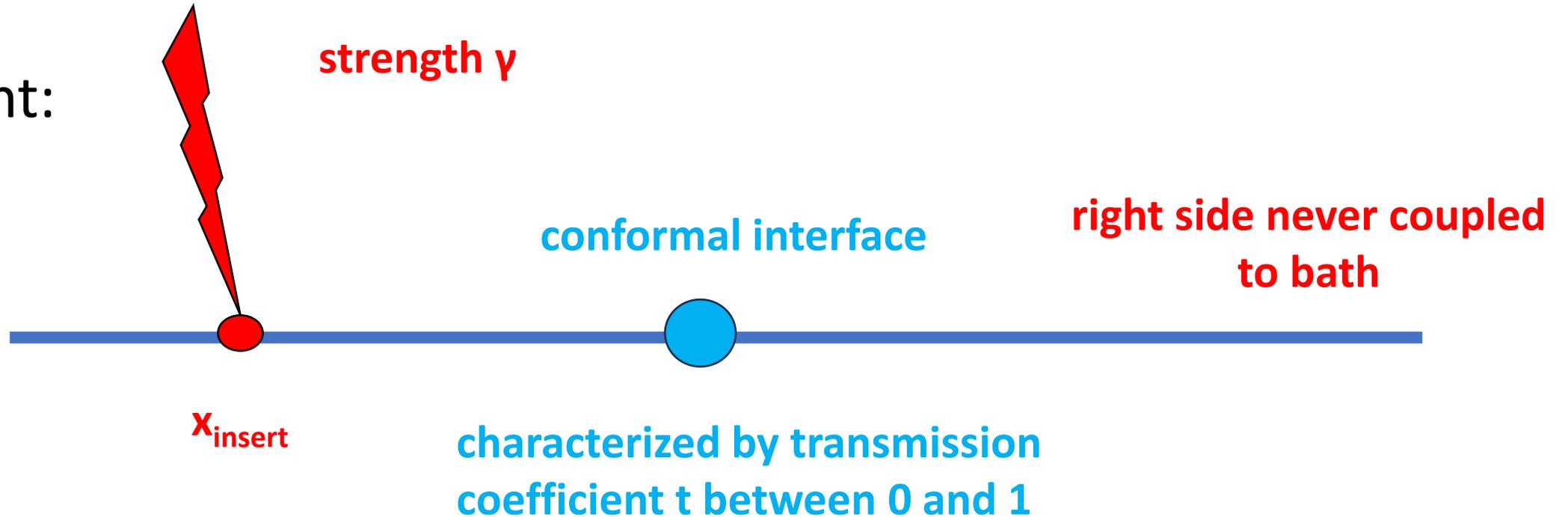


- at very large h we return to 2 decoupled modes
- but with different real / imaginary values for the QNM as we exchanged alternate with standard quantization!

Open Holographic Interfaces

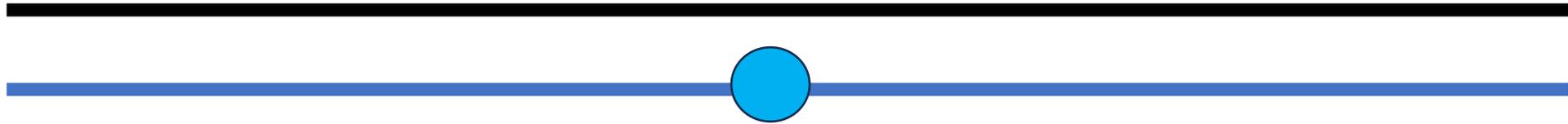
(Wang, AK)

Want:



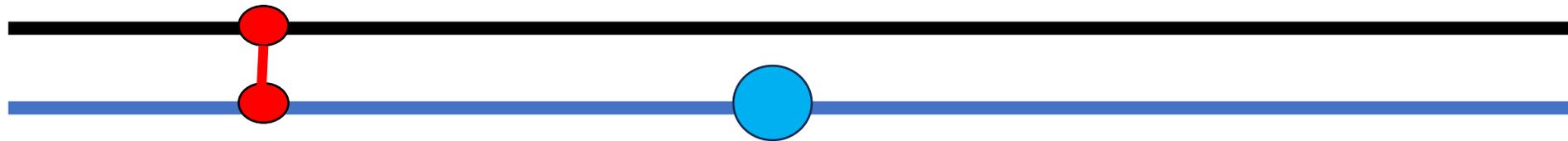
Open Holographic Interfaces

**Decoupled bath CFT,
finite T**



ICFT remains at zero T

Open Holographic Interfaces



x_{insert}

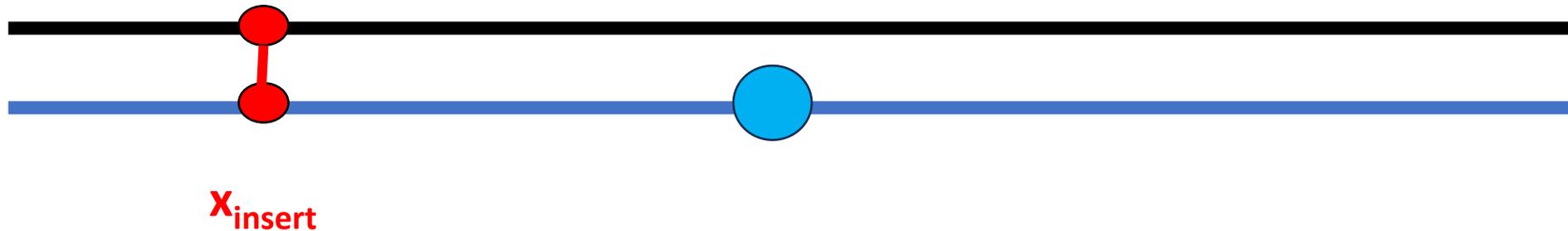
**add local double trace
coupling on left of interface**

3 parameters in dissipation:

- Dimension Δ (mechanism)
- Coupling h (strength)
- x_{insert} (location)

Open Holographic Interfaces

Does c_{relax} depend on these 3 parameters, or is it universal?

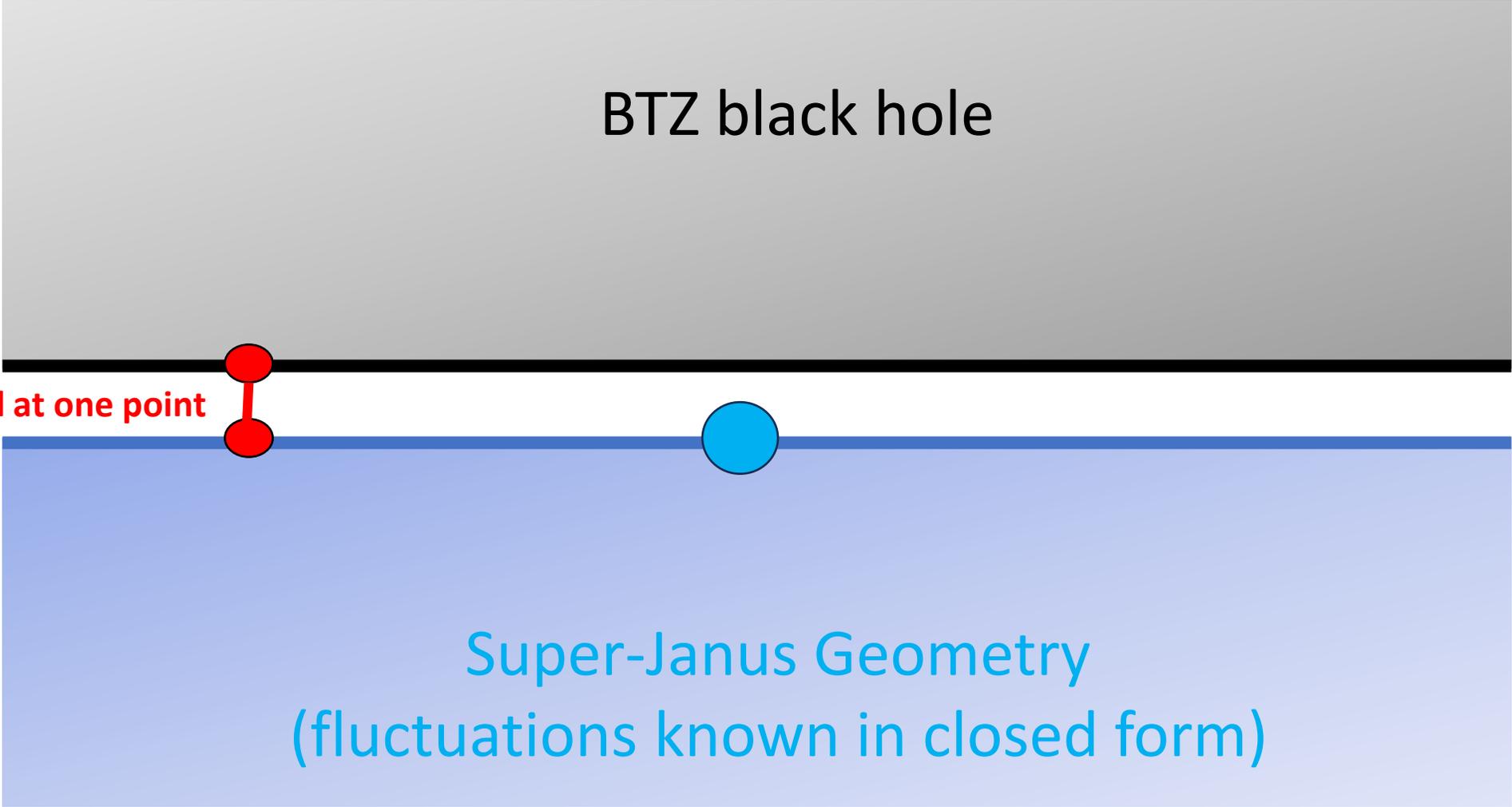


add local double trace coupling on left of interface

- 3 parameters in dissipation:
- Dimension Δ (mechanism)
 - Coupling h (strength)
 - x_{insert} (location)

Open Holographic Interfaces

BTZ black hole



The diagram illustrates an open holographic interface. It consists of two horizontal rectangular regions. The top region is gray and labeled 'BTZ black hole'. The bottom region is light blue and labeled 'Super-Janus Geometry (fluctuations known in closed form)'. A thick black horizontal line separates the two regions. On the left side, two red circles are connected by a vertical red line, with the text 'BC linked at one point' in red to their left. On the right side, a single blue circle is positioned on the interface line.

BC linked at one point

Super-Janus Geometry
(fluctuations known in closed form)

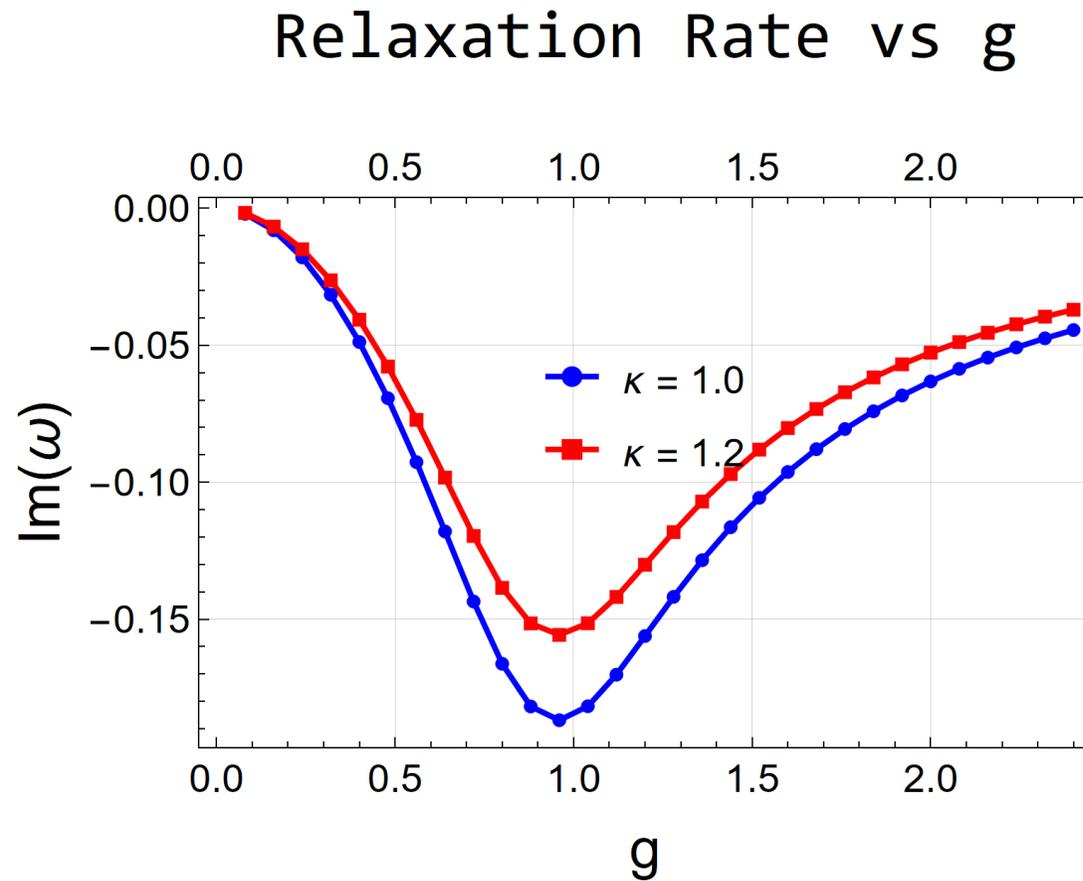
Details

- Standard D BC except for insertion point, where we impose

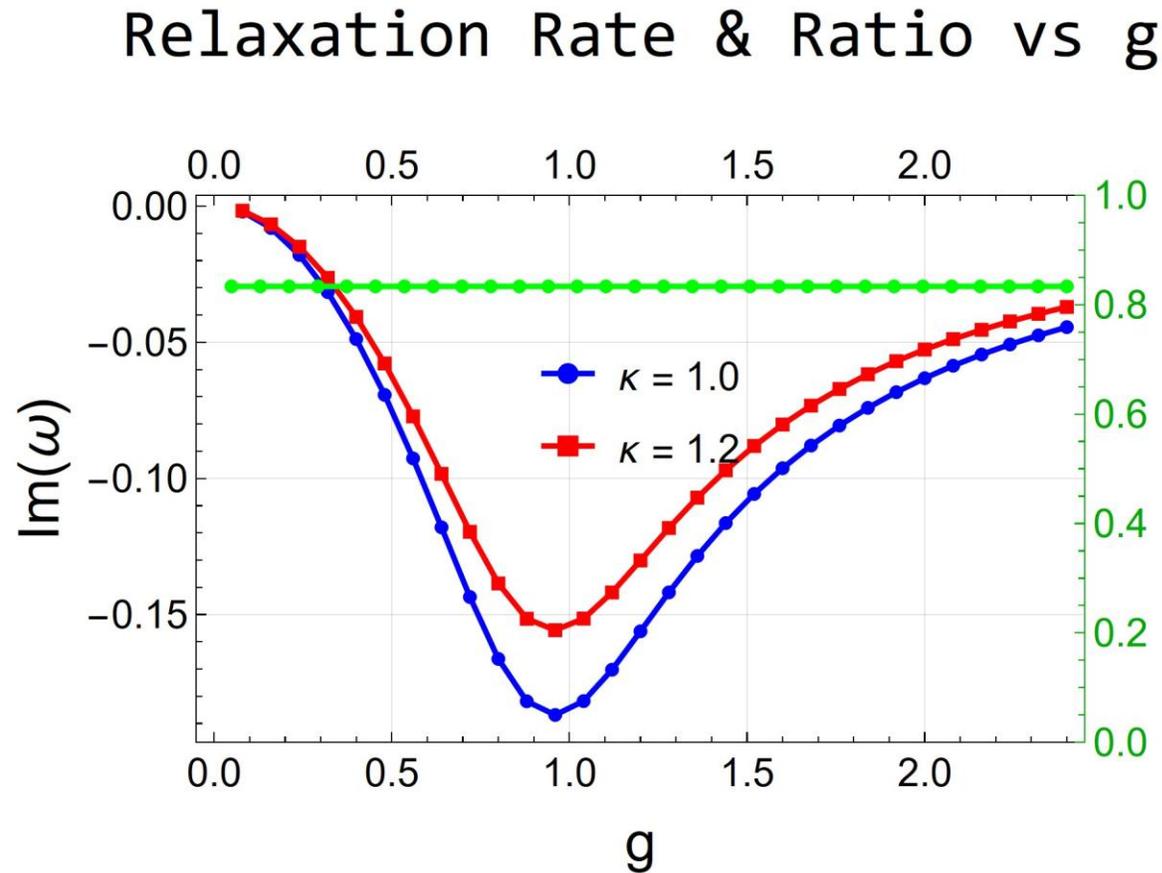
$$\alpha_L(\vec{x}) = h(2\Delta - d)\beta_R(\vec{x}), \quad \alpha_R(\vec{x}) = h(2\Delta - d)\beta_L(\vec{x})$$

- Before coupling real normal modes in super-Janus, imaginary QNM in BTZ
- **smallest imaginary part** of a QNM after coupling sets relaxation rate
- To get c_{relax} we need to do this with and without interface and form the ratio

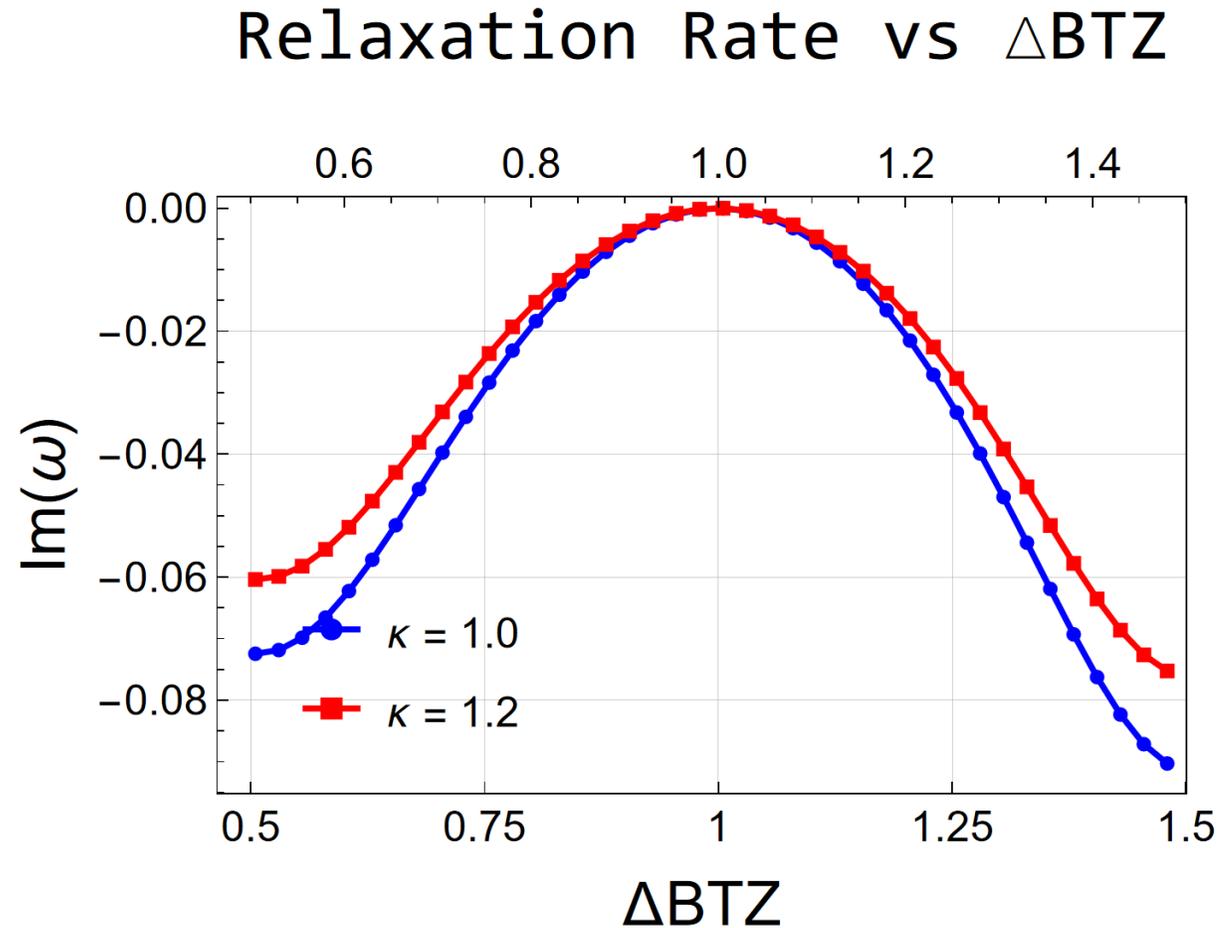
Relaxation time as a function of coupling



Relaxation time as a function of coupling

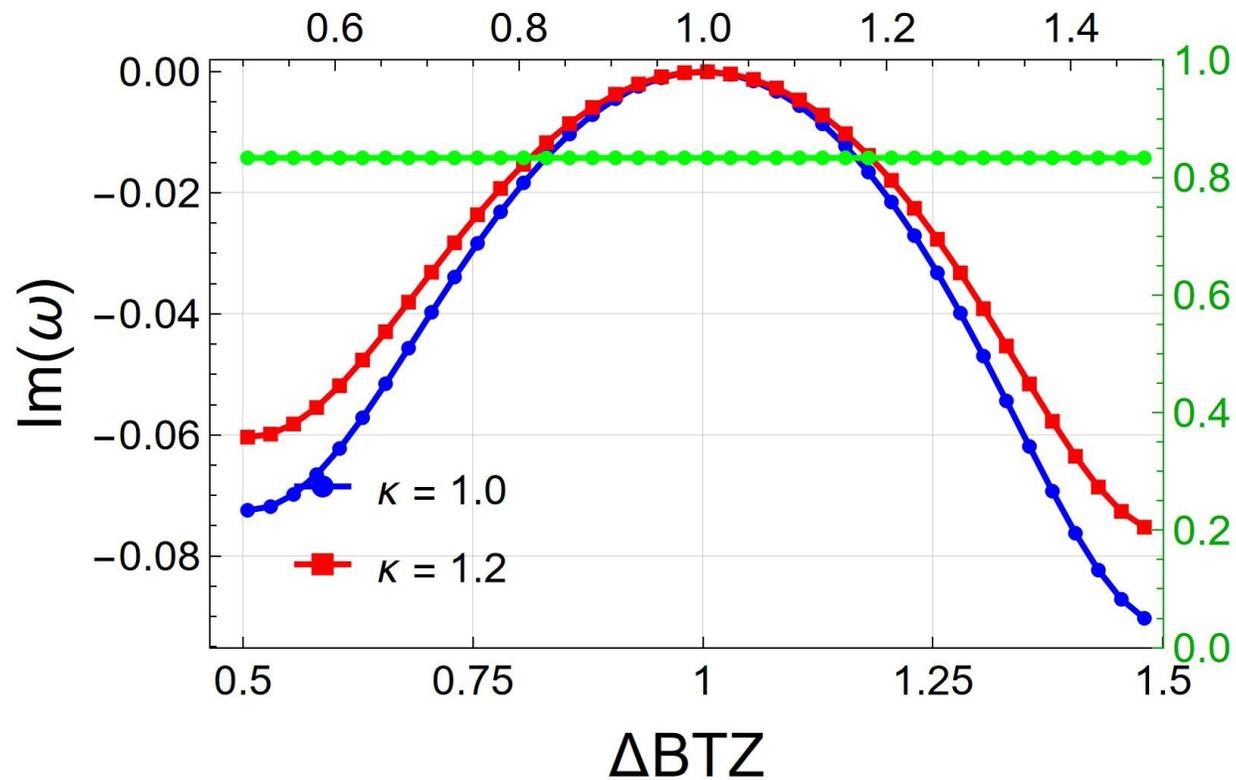


Relaxation Rate as a function of Delta

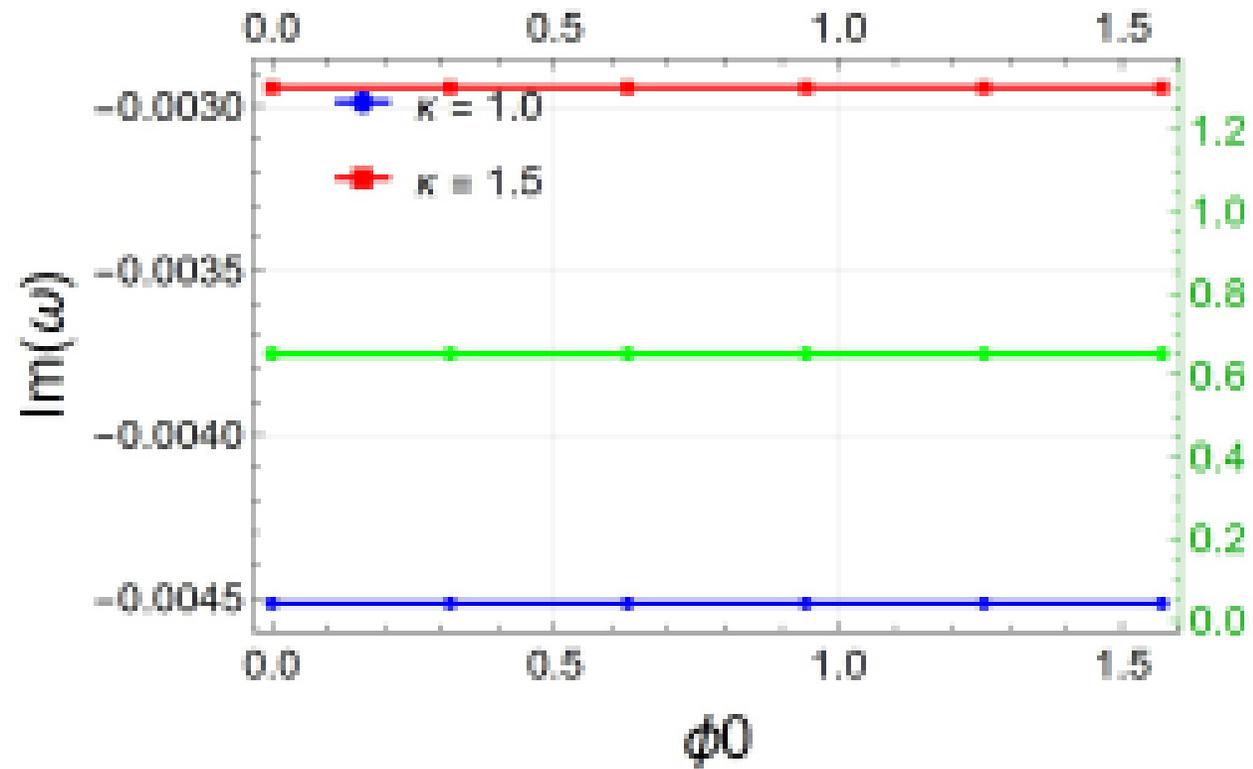


Relaxation Rate as a function of Delta

Relaxation Rate & Ratio vs Δ BTZ



Relaxation Rate as a function of Insertion



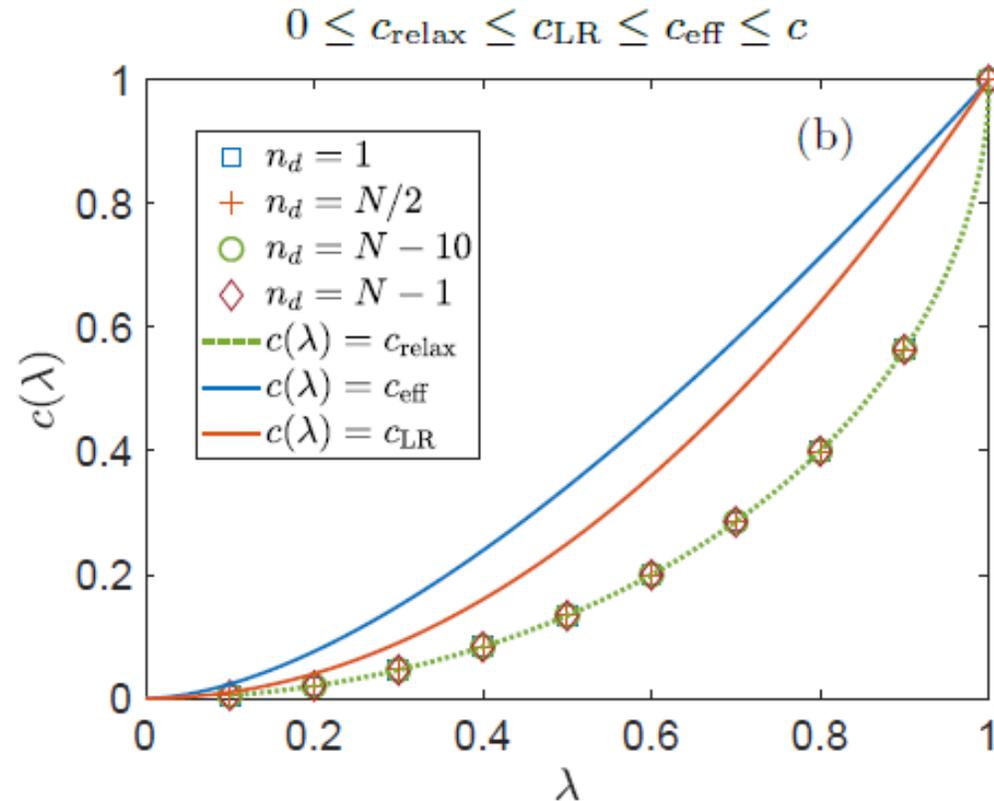
It works!

Within the precision of our numerics (about one part in 10,000) c_{relax} is **independent** of:

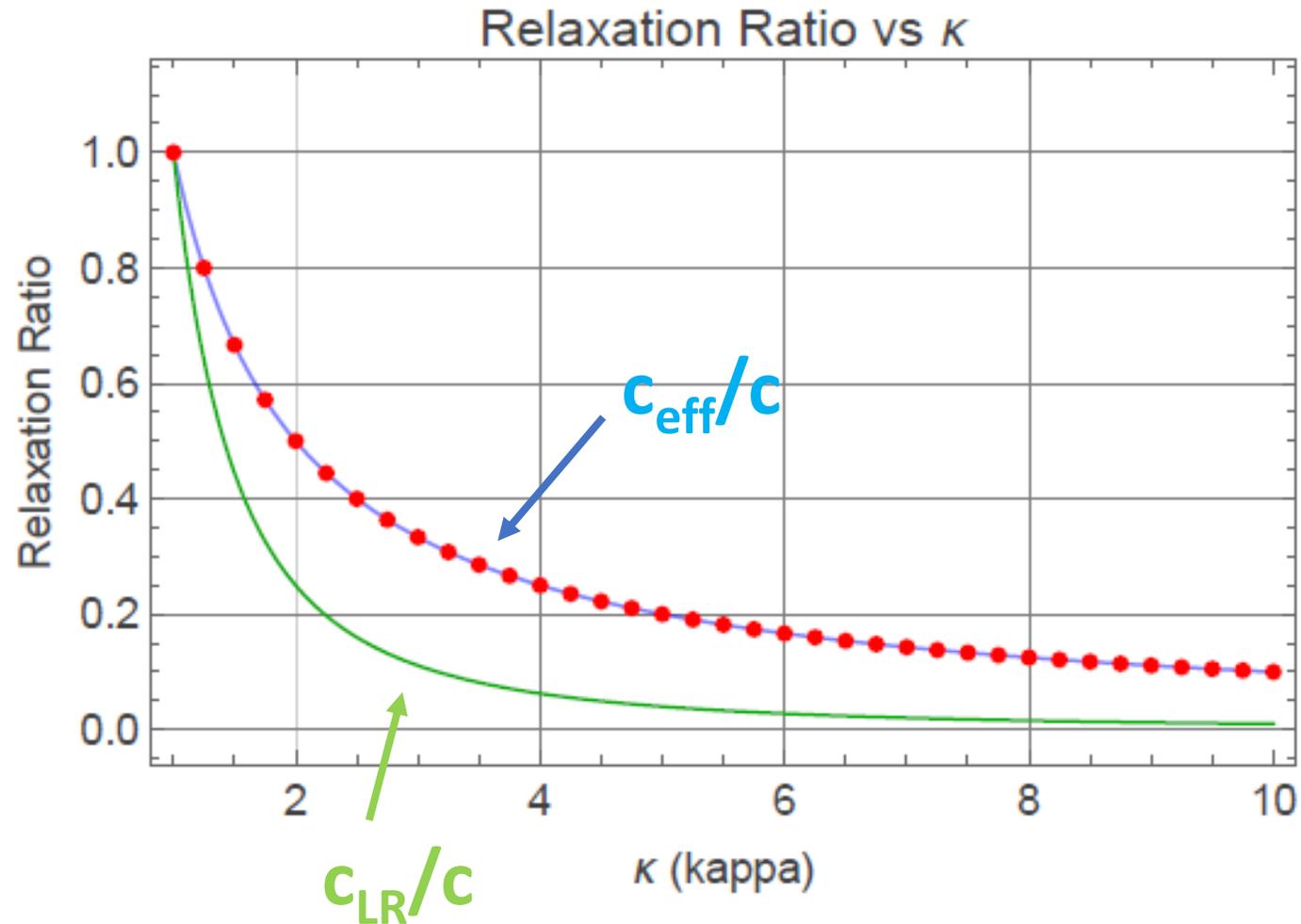
- Dissipation mechanism
- Dissipation strength
- Dissipation location

Remaining question: Where does it fall?

Recall from free fermion:



Holographic picture:



red dots:

c_{relax}/c

It appears that

$c_{\text{relax}} = c_{\text{eff}}$

in super-Janus!!!

Supersymmetry?

Conclusions:

- Thinking about dissipation in the presence of interfaces appears to give rise to a new universal quantity characterizing 2d conformal interfaces
- Universality observed in **free fermions** and **holographic super-Janus solution**
- In free fermions genuinely new quantity, in super-Janus degenerate with previously known c_{eff}

What to do next?

- More examples (free Boson? non-SUSY Janus?)
- Analytic answers? Universality and $c_{\text{relax}} = c_{\text{eff}}$ should not require numerics. We're just solving scalar wave equation.
- Ordering? Bounds?
- Are there other applications for dissipation in classifying field theories?