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FINITE-T PHASE DIAGRAM OF 2D QUANTUM SYSTEMS THROUGH GLOBAL TNR

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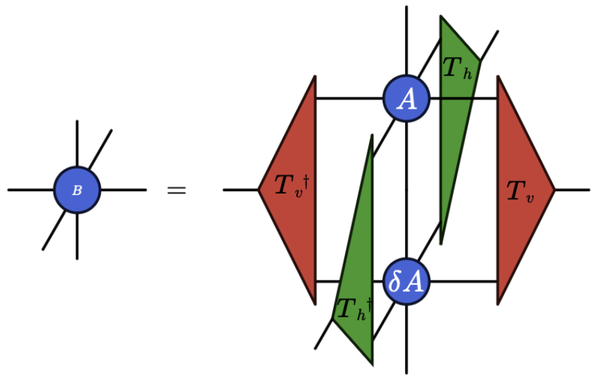
arXiv:2508:05406

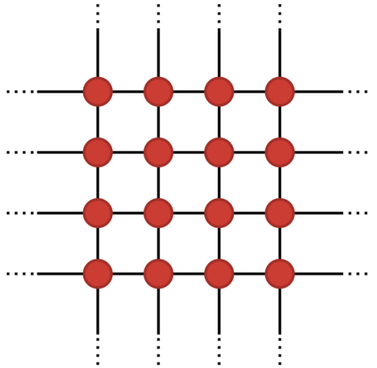
RECAP

RG in β direction

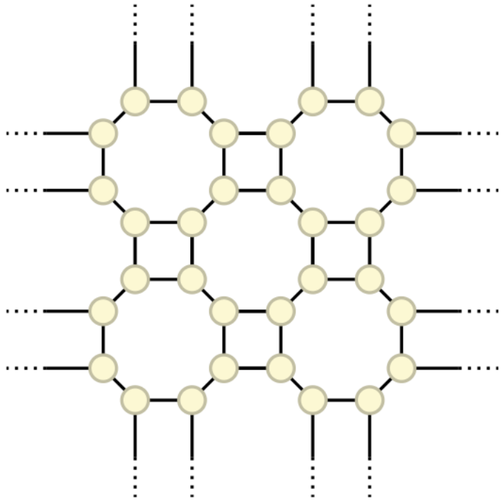


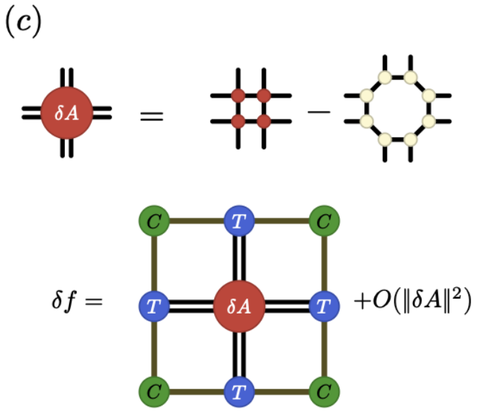
Contract the physical leg

2d tensor network



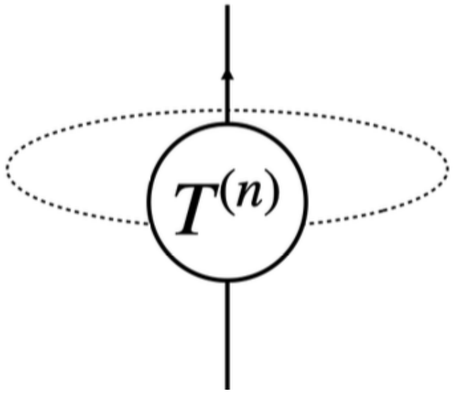
Global TNR





Critical spectrum from transfer matrix of the renormalized tensors

$$\Lambda = e^{-2\pi\Delta}$$



$$C(A) = \|\delta A\|^2 + \alpha\|\Gamma_{\text{env}}\delta A\|^2$$

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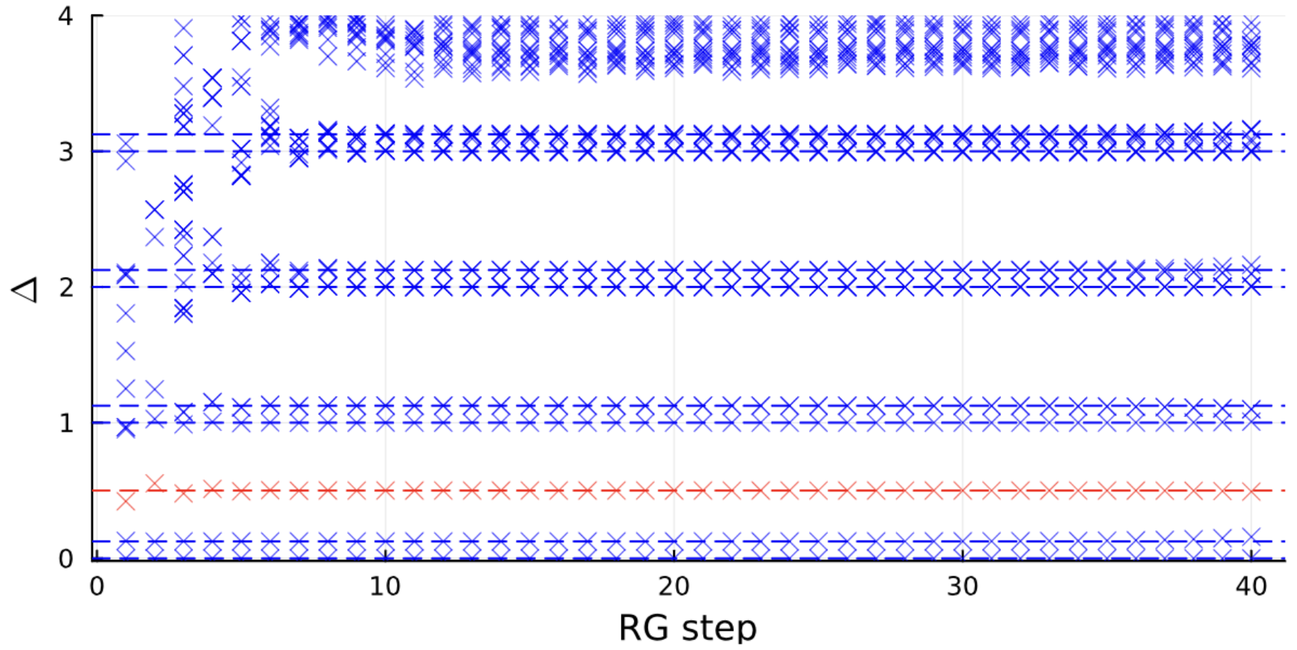
BENCHMARKING: CLASSICAL ISING

Free energy error at criticality

δf	TRG	GTRG	CTMRG	Loop TNR	Current work
Ising	$9.8 \cdot 10^{-6}$	$6.9 \cdot 10^{-7}$	$2.7 \cdot 10^{-7}$	$3.5 \cdot 10^{-8}$	$8.5 \cdot 10^{-10}$

Critical spectrum



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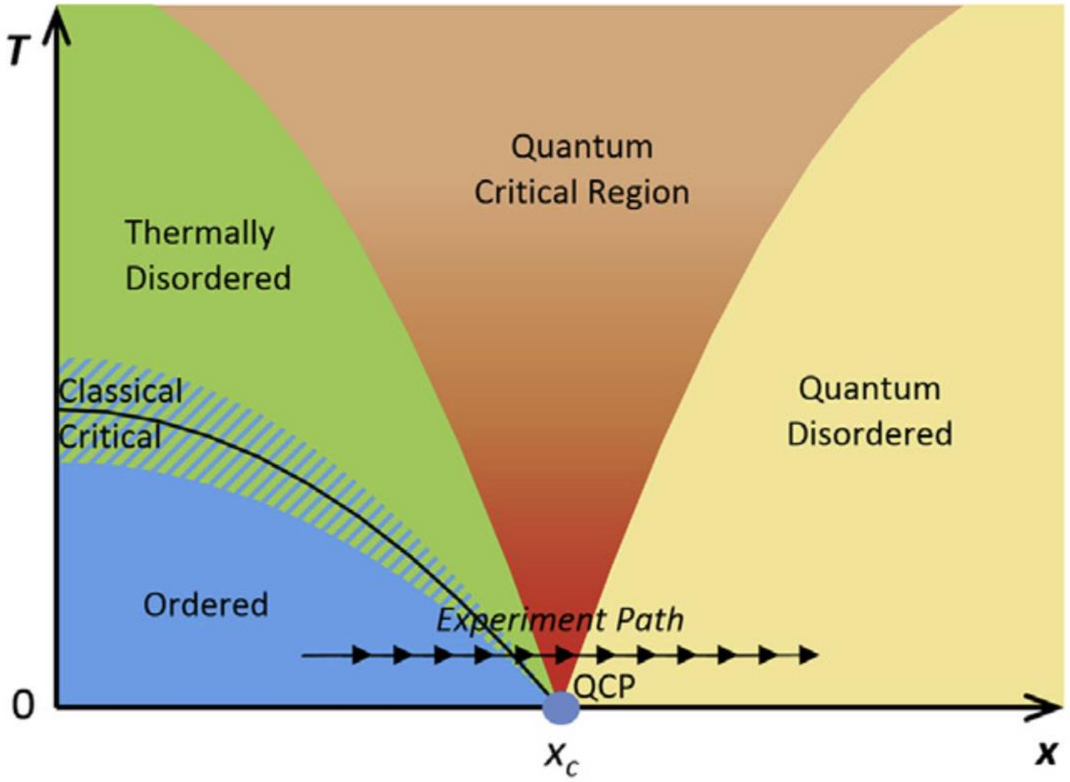
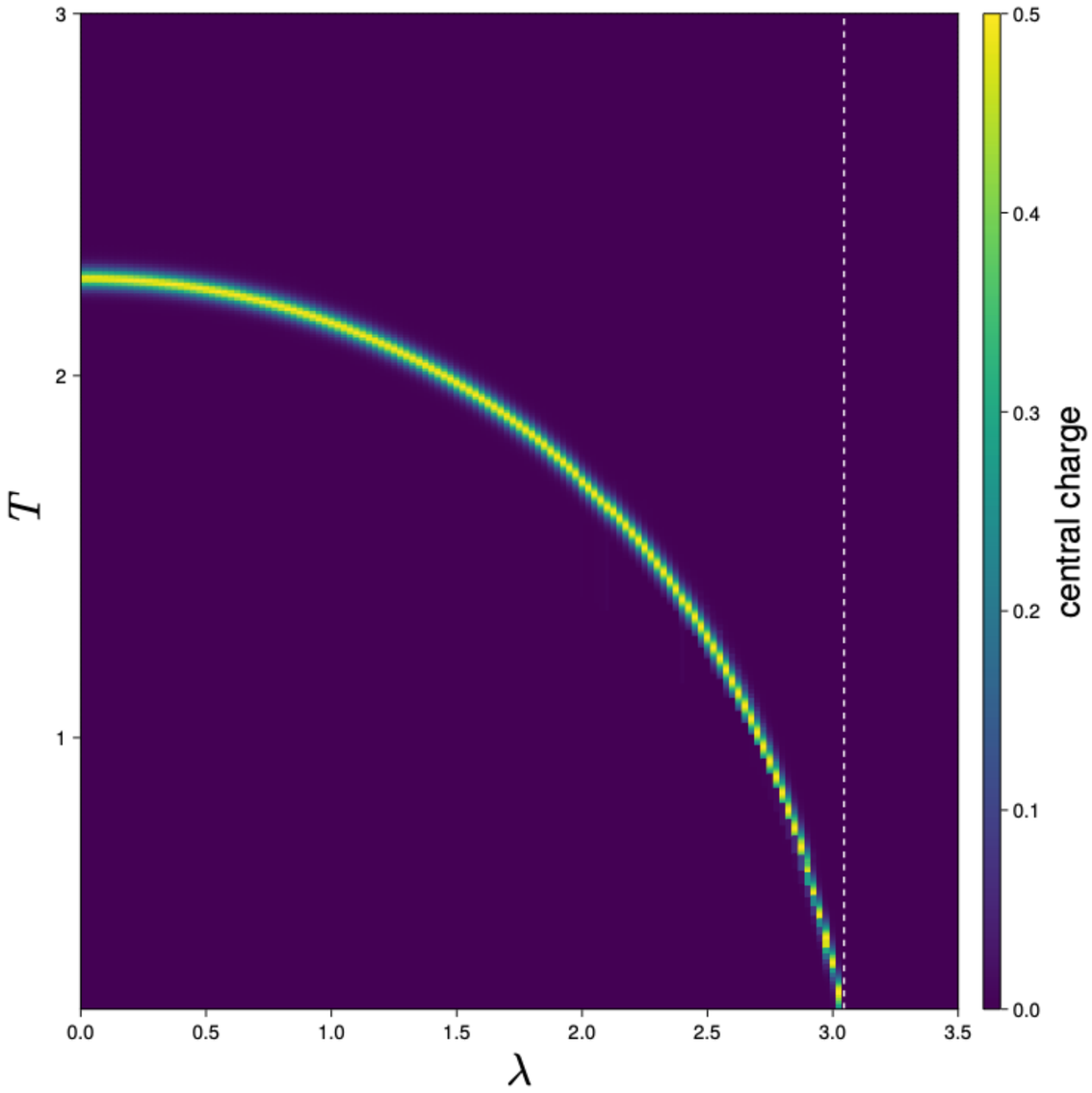
2D QUANTUM TF ISING

$$H = -\sum_{\langle i,j \rangle} \sigma_i^z \sigma_j^z - \lambda \sum_i \sigma_i^x$$



Thermal TNR



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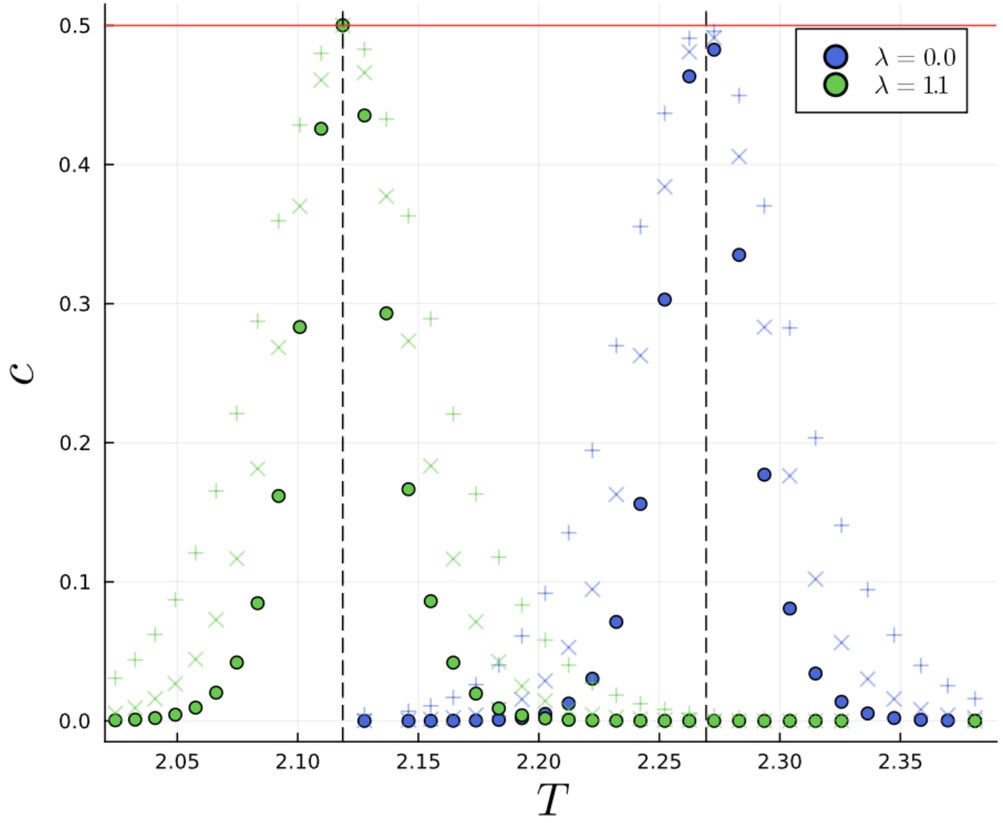
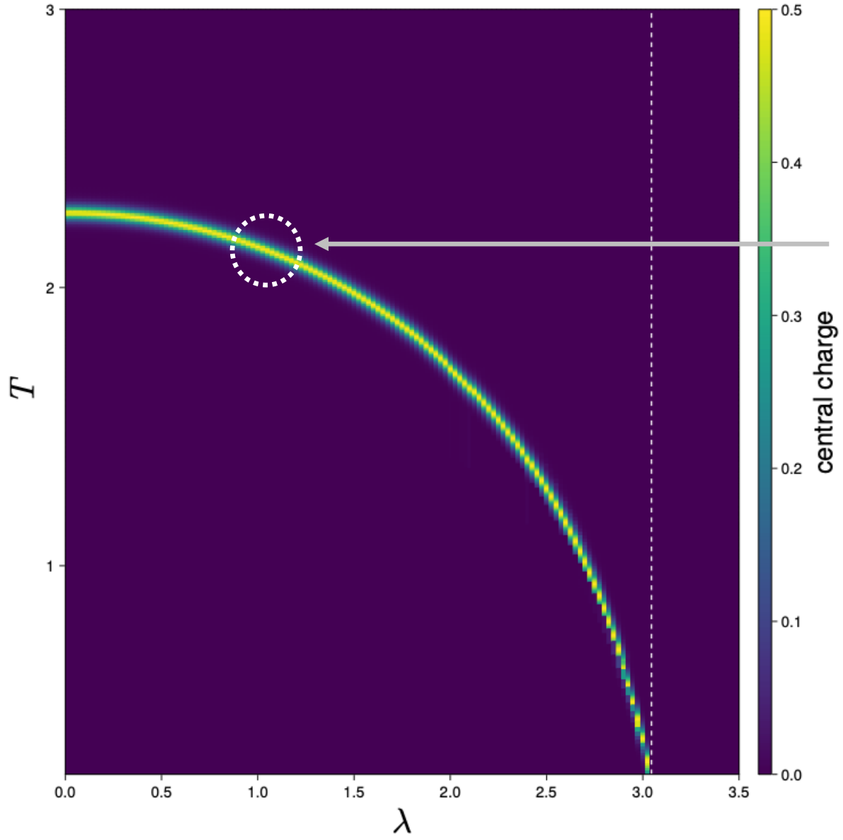
2D QUANTUM TF ISING

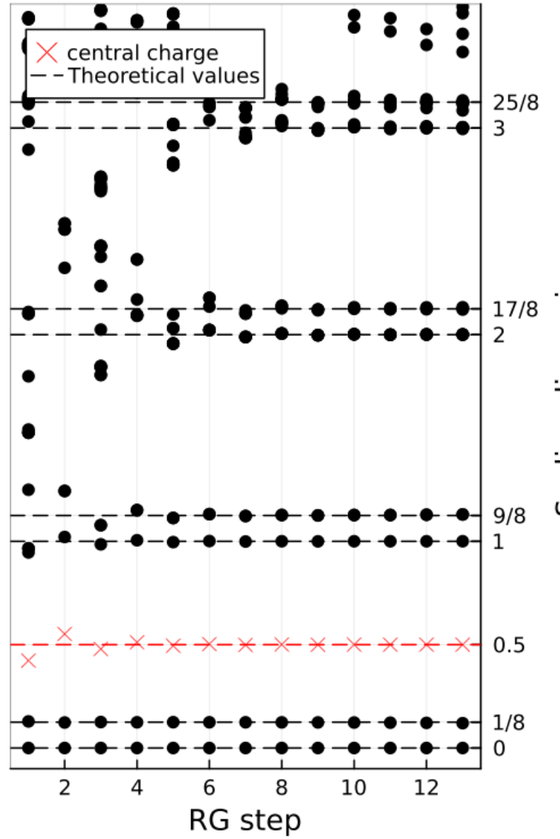
Thermal TNR



(a)



(b)



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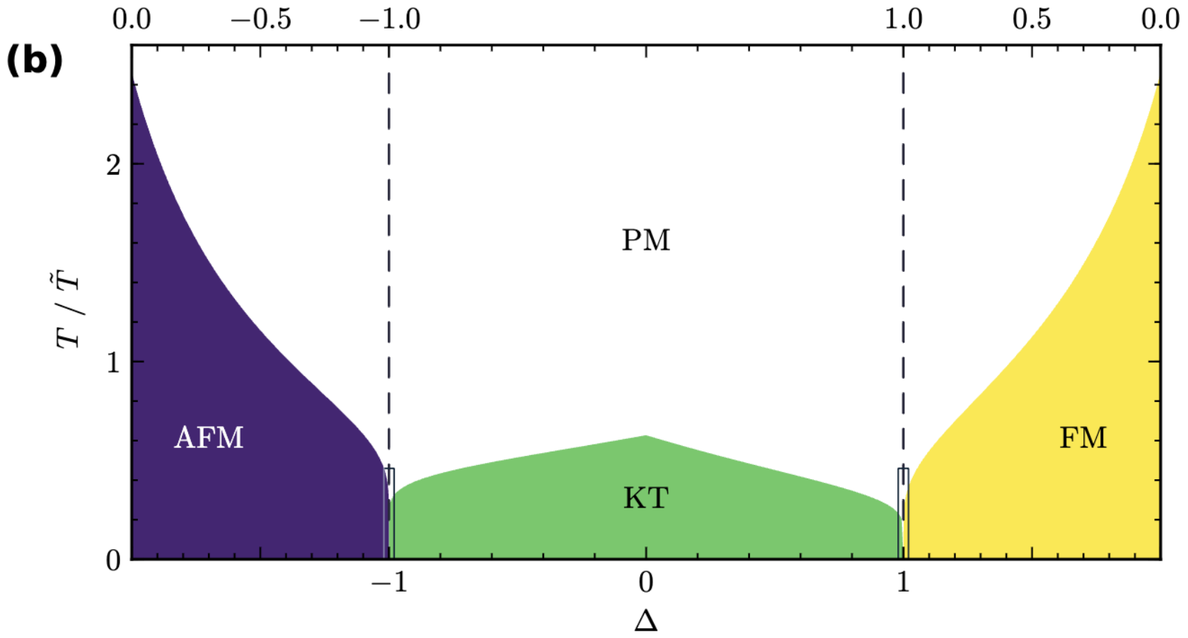
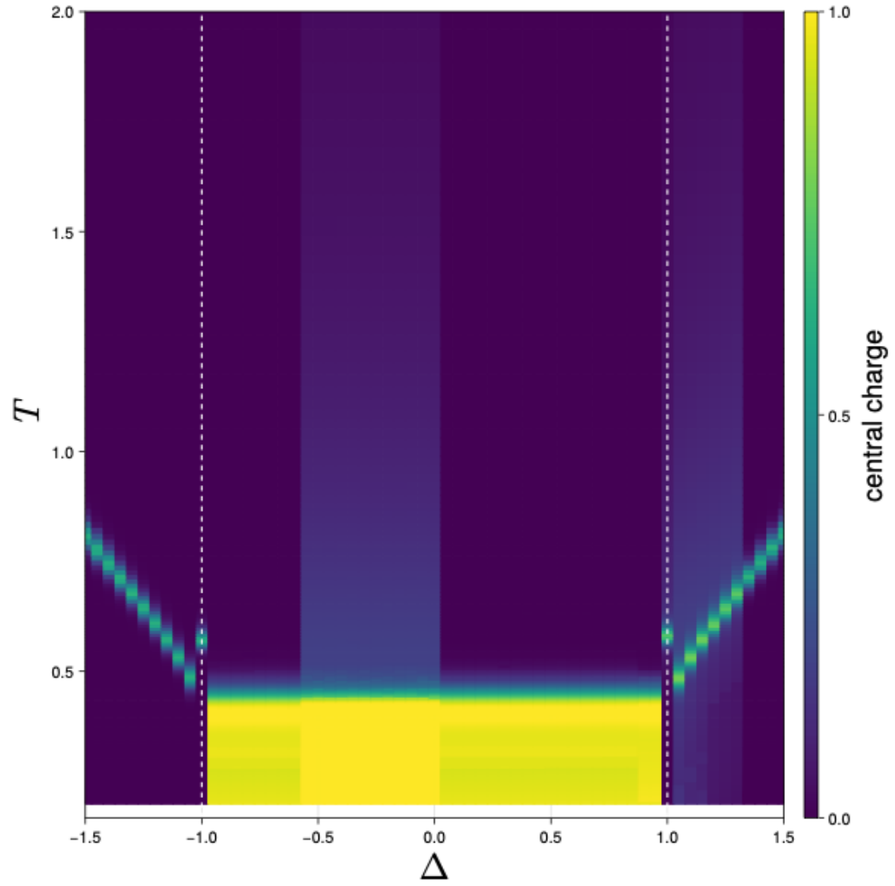
2D QUANTUM XXZ

$$H = J \sum_{\langle i,j \rangle} \left(S_i^x S_j^x + S_i^y S_j^y + \Delta S_i^z S_j^z \right)$$





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Summary

- Global optimization of TNR enables accurate contraction of a two-dimensional tensor network.

- We can extract CFT data from thermal transitions of 2d quantum states.

Future direction

- Apply our methodology to non-trivial models such as J1-J2 model

- Develop similar methodologies for QCP (3d CFT)

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Most computation can be done on your laptop!😘

TNRKit.jl