Localization transition in SU(3) gauge theory

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Finite temperature transition in QCD

Finite temperature transition of quarks:

hadronic state $\rightarrow$ quark-gluon plasma

Around the crossover temperature three phenomena occur

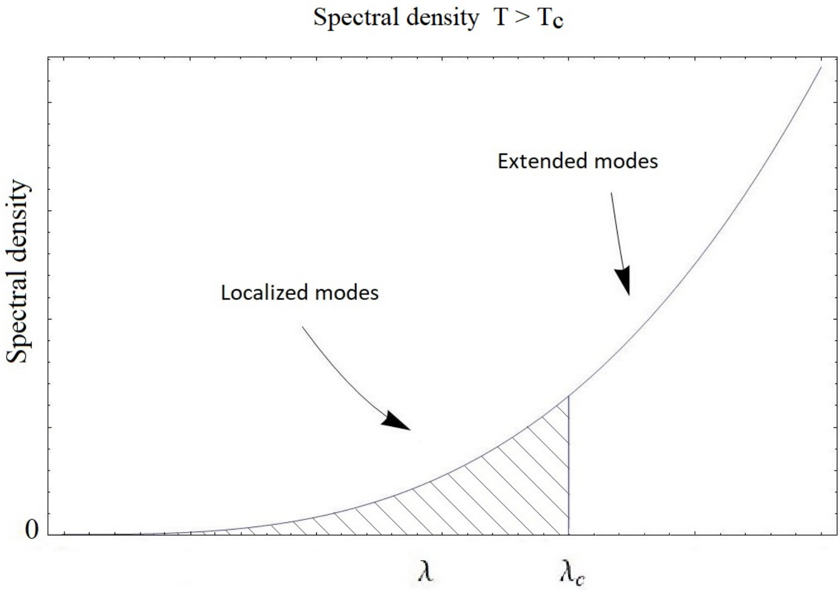
Thermodynamic transition:

- confined $\rightarrow$ deconfined
- broken chiral symmetrs $\rightarrow$ chiral symmetry restoration

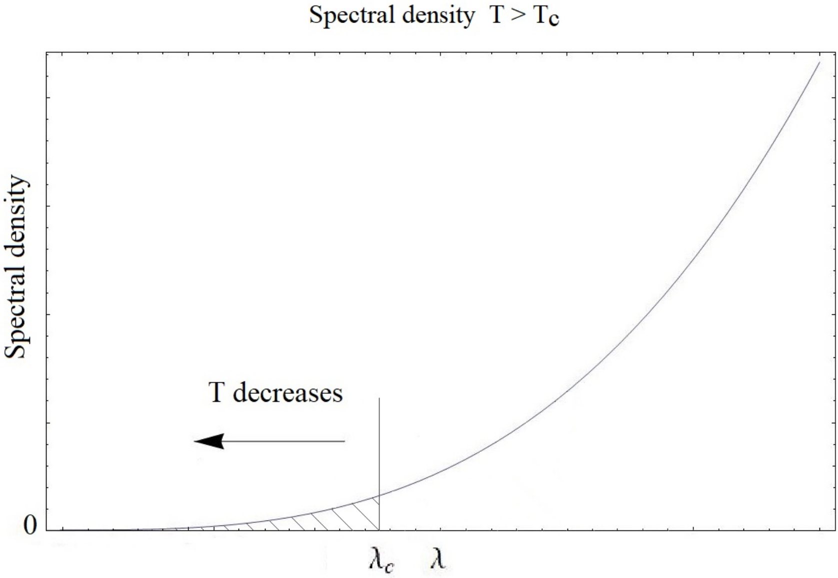
Localization transition:

- low eigenmodes of the Dirac operator become localized

Mobility edge



Mobility edge



Aim of our work

low $T \rightarrow$ extended modes   high $T \rightarrow$ low modes are localized

Somewhere between $({T_c}^{\text{loc}}) \rightarrow$ the localized modes (dis)appear

- We want to know ${T_c}^{\text{loc}}$ where localized modes appear
- Quenched QCD$\rightarrow$ genuine phase transition
- Is ${T_c}^{\text{loc}} = {T_c}^{\text{deconf}}$?
- If yes $\rightarrow$ the three phenomena are related

Critical temperature of localization

How to find ${T_c}^{\text{loc}}$?

$\rightarrow$ Determine λ_c for different temperatures above ${T_c}^{\text{deconf}}$

${T_c}^{\text{loc}}$ will be the temperature where λ_c disappears:

$\lambda_c({T_c}^{\text{loc}}) = 0$

to find λ_c at some T $\rightarrow$ check the statistics

Statistics of extended and localised modes

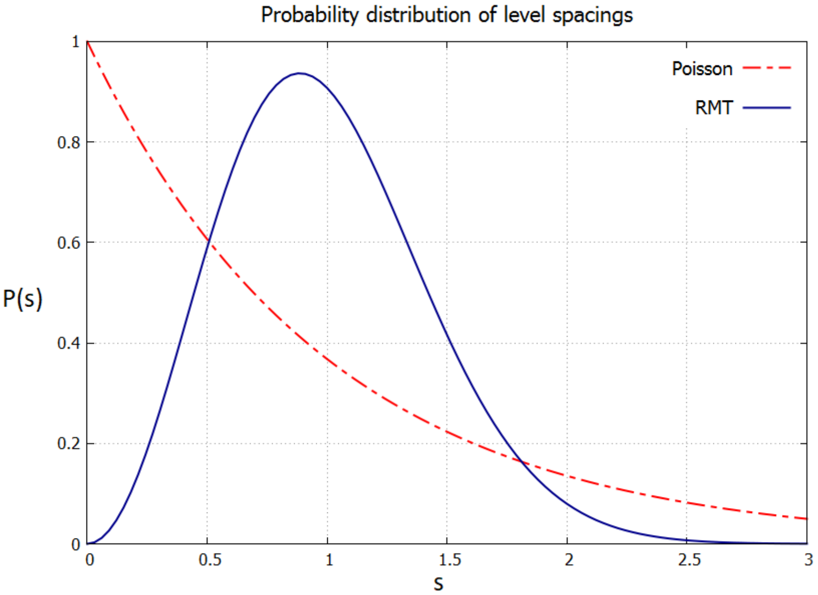
- extended modes are mixed by the gauge field
  $\rightarrow$ eigenvalues obey Wigner-Dyson statistics (RMT)

- localized modes are independent
  $\rightarrow$ eigenvalues obey Poisson statistics

Determine the mobility edge at some $T \rightarrow$ e.g. unfolded level spacing statistics

Analytic predictions are known for the unfolded spectrum.

Poisson and Wigner-Dyson statistics



Determine the statistics

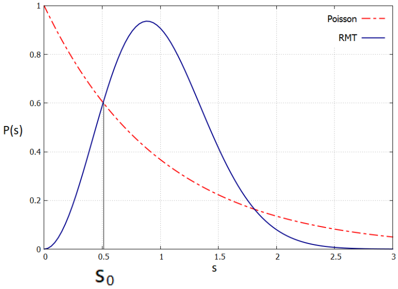
Follow the change from localized modes to extended modes in the spectrum:

$\rightarrow$Divide the spectrum into small bins

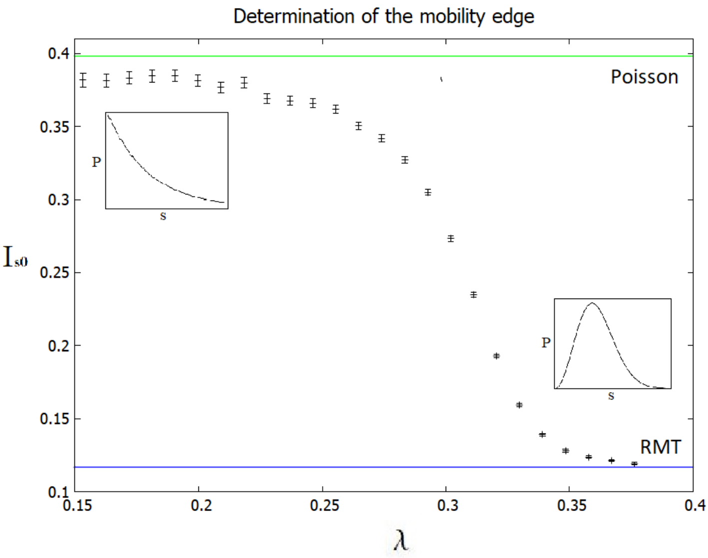
$\rightarrow$Calculate a parameter of the statistics for each

Parameter$\rightarrow$ the integrated probability distribution function

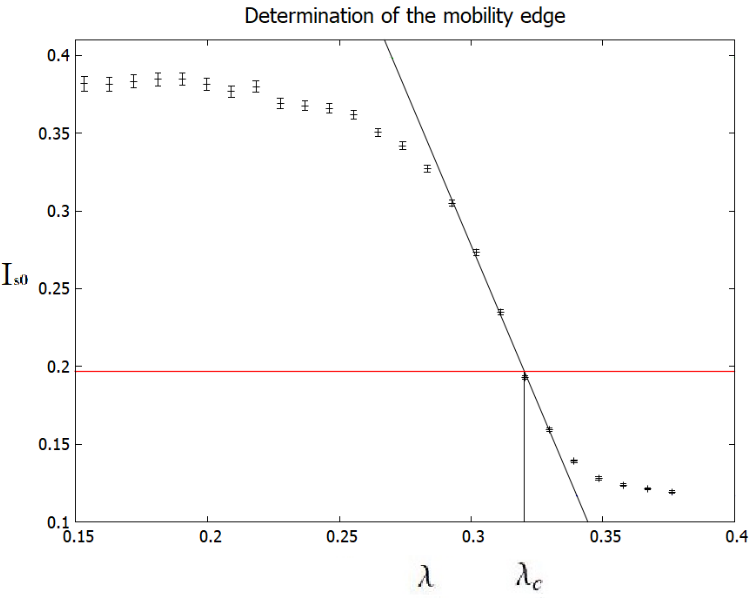
$$I_{s_0}(\lambda) \equiv \int_0^{s_0} P_\lambda(s) ds$$



Mobility edge from $I_{s0}(\lambda)$



Mobility edge from $I_{s0}(\lambda)$



The method

Change the gauge coupling β (temperature) $\rightarrow$ get points of $\lambda_c(\beta)$ for fixed N_t

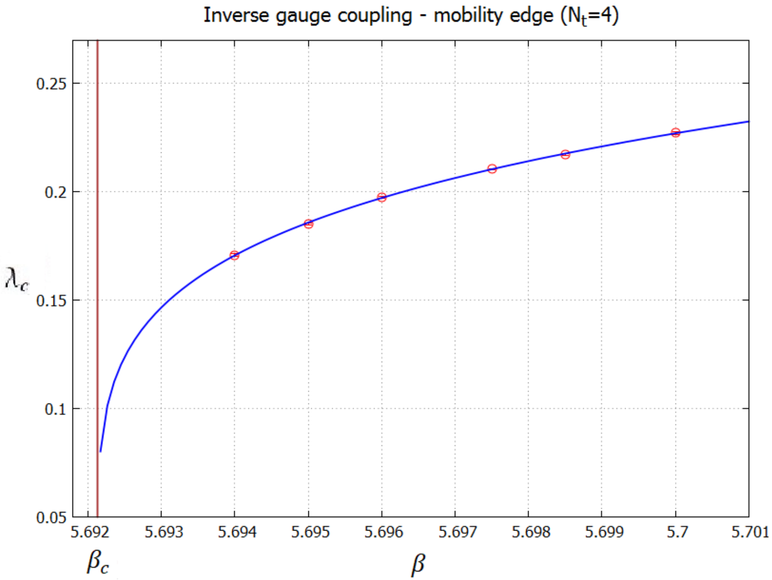
Then extrapolate ${\beta_c}^{\text{loc}}$ with a power function: $p_1(x - \beta_c)^{p_2}$

We calculated ${\beta_c}^{\text{loc}}$ for lattices with temporal extensions:

$$N_t = 4, 6 \text{ and } 8$$

with staggered fermions + 2 stout

Extrapolation of the mobility edge



Comparsion of β_c for localization and deconfinement

We determined β_c for three lattice spacings

N_t	${\beta_c}^{\text{deconf}}$	${\beta_c}^{\text{loc}}$
4	5.69254(24)	5.69246(50)
6	5.8941(5)	5.8935(16)
8	6.0624(10)	6.057(4)

Overlap operator

Do the same procedure with overlap operator for $N_t = 6$

N_t	${\beta_c}^{\text{deconf}}$	${\beta_c}^{\text{loc}}$
6	5.8941(5)	5.8927(64)

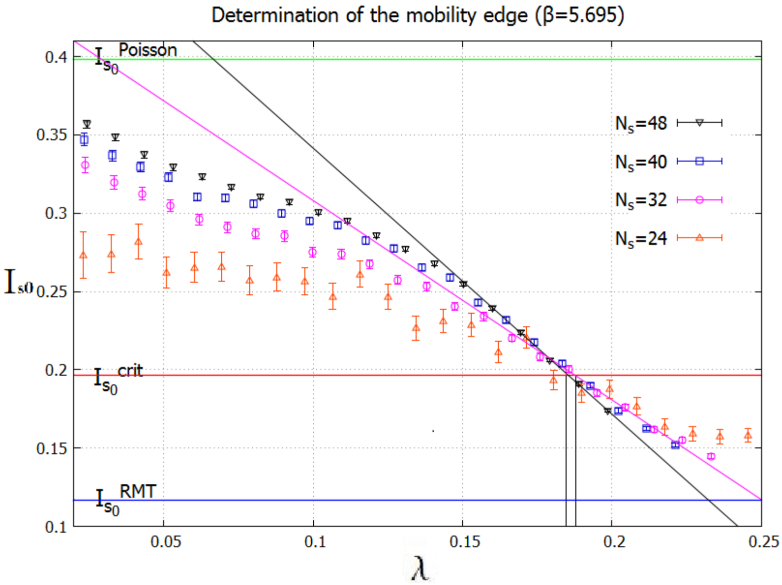
Summary and outlook

- Quenched QCD: a real first order deconfining/chiral phase transition
- Localization$\rightarrow$ same β_c for localization and deconfinement
- Checked for staggered $N_t = 4, 6, 8$ and overlap $N_t = 6$
- Overlap: connection between localization and topology $\rightarrow$ see next talk

The end

Thanks for your attention!

Points very close to β_c



Parameters

	N_t	fit range (β)	N_s	conf num (for one β)	eval num (for one conf)
staggered	4	5.695-5.71	32-48	2000	1000
	6	5.91-5.96	32-48	1000	1000
	8	6.08-6.18	48-64	700	600
overlap	6	5.91-5.96	32-40	300	80

Parameters

$$I_{s_0}^{Poisson} = 0.398, \qquad I_{s_0}^{RMT} = 0.117, \quad I_{s_0}(\lambda_c) \equiv I_{s_0}^{crit} = 0.1966$$