Nearly conformal electroweak sector with chiral fermions

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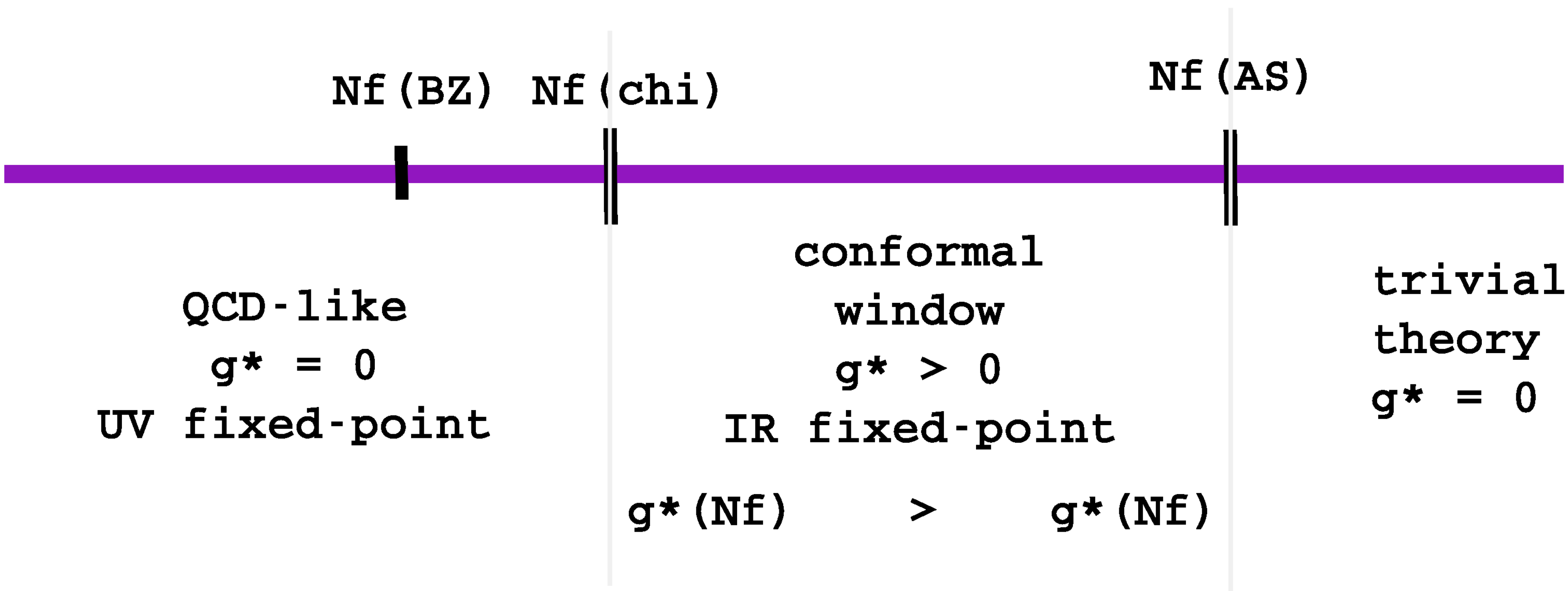
Outline and motivation

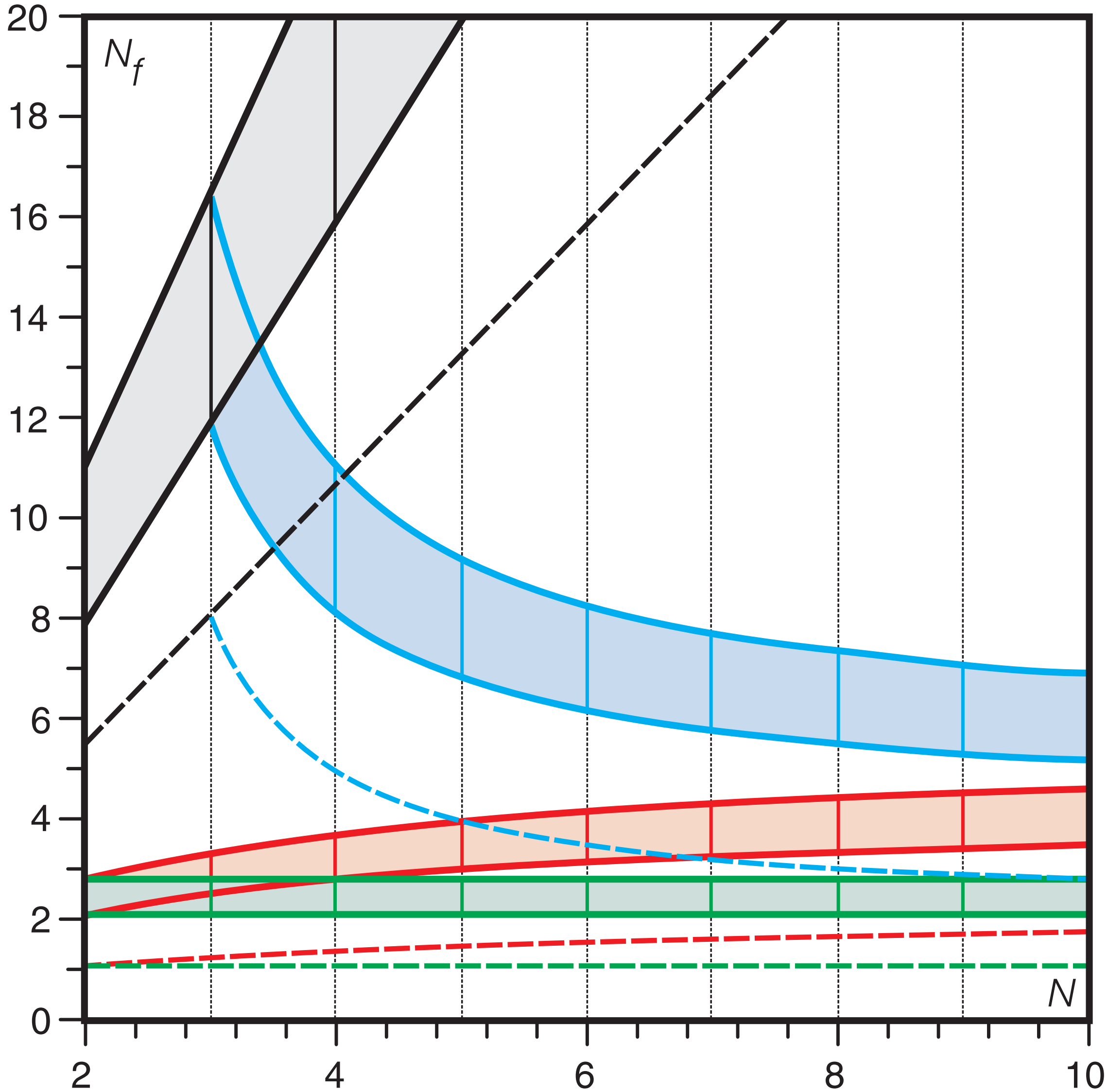
- BSM Higgs sector
  - Heavy Higgs?
  - Strongly interacting EW symmetry breaking?
- Technicolor idea
  - Walking - nearly conformal
  - Conformal
- Phase diagram of gauge theories (N_c, N_f, R)
  - QCD
  - SUSY YM
  - Other representations?
- Unparticles - conformal hidden sector

Phase diagram (N_c, N_f, R)



($\mathcal{N} = 1$ YM is a special case)

Phase diagram (N_c, N_f, R) in perturbation theory



Fundamental: gray

(Pallante, Neil, Jin, Deuzeman today, Holland Friday 3:50, Fleming Saturday 9:15)

2 antisym: blue

2 sym: red

adjoint: green

(Sannino)

Technicolor paradigm

Need to know $N_f(\chi)$ for fixed N_c, R

A constraint from phenomenology: S-parameter $\sim dim(R)N_f$ should be small

$SU(3)$ fundamental representation is ruled out

(JLQCD: non-perturbative $\sim$ perturbative)

$SU(3)$ 2S representation produces right number of Goldstones from symmetry breaking

$N_f(BZ) = 1.2$ $\qquad$ $N_f(\chi) = 2.5$ $\qquad$ $N_f(AS) = 3.3$

$N_f = 2$ just below conformal window - could be walking

If really in conformal window: good for conformal technicolor

(Luty)

Our model

$SU(3)$ $\qquad$ $N_f = 2$ $\qquad$ $R = 2S$

Simplest model with small S-parameter, 3 Goldstone-bosons (get eaten by W, Z), EW symmetry breaking works out

Chiral symmetry is important: use dynamical overlap fermions

Previous study: wilson fermions + Schrodinger functional: maybe conformal

Svetitsky (Friday 2:30) DeGrand (Friday 2:50)

Problems everyone in this business has to deal with

Small bare coupling (small volume): always free

Large bare coupling: always χSB

Staggered: taste breaking, effective $N_f <$ naive N_f

Wilson: explicit χSB

Overlap: strong coupling phase diagram complicated, little is known very expensive

Most important question: how to distinguish χSB from conformal?

χSB vs. conformal

Possible methods

- β-function from Schrodinger functional (Appelquist et al.)
- Locating finite T transition (Pallante et al.)
- ε-regime $\rho(\lambda)$ characteristics (Fodor/Holland/Kuti/DN/Schroeder)

ε-regime and Dirac spectrum

If χSB and $1/f_\pi < L < 1/m_\pi$

Can use chiral Lagrangian without kinetic term

Detailed prediction for microscopic Dirac spectral density $\zeta = \lambda \Sigma V$ and eigenvalue distributions in each Q topological sector, calculable with RMT

$$\rho_S(\zeta) = \frac{1}{\Sigma V} \rho\left(\frac{\zeta}{\Sigma V}\right) = \sum_{k=0}^{\infty} p_k(\zeta)$$

For macroscopic $\rho(\lambda)$: Banks-Casher: $\rho(0) = V\Sigma/\pi$

ε-regime and Dirac spectrum

In conformal case: no ε-regime or microscopic spectral density

$$\rho(\lambda) \sim \lambda^{3+\gamma}$$

γ anomalous dimension of $\bar{\psi}\psi$

Unfortunately $p_k(\lambda)$ not known, in principle calculable (work in progress)

Effect of finite m and finite V also not known (work in progress)

Strategy: simulate in real or would-be ε-regime and see if $\rho_S(\zeta)$ and/or $\rho(\lambda)$ is or is not consistent with RMT and/or conformal predictions

Algorithms for dynamical overlap

- Hungarian (reflection/refraction)
- Japanese (topology conserving with extra wilson fermion)

We need fix Q, Japanese algorithm cheaper: use that for initial study

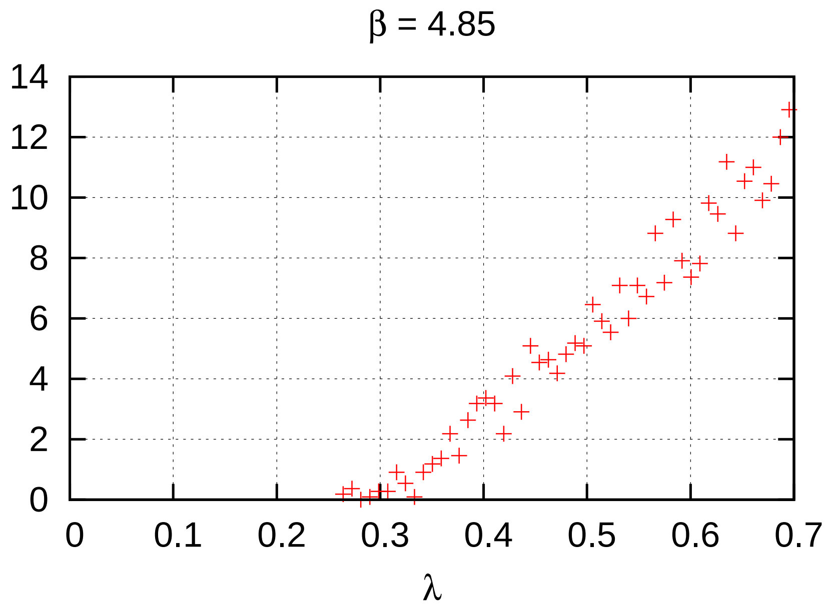
Preliminary results, 6^4 volume, $m = 0.05$, $O(100)$ configurations

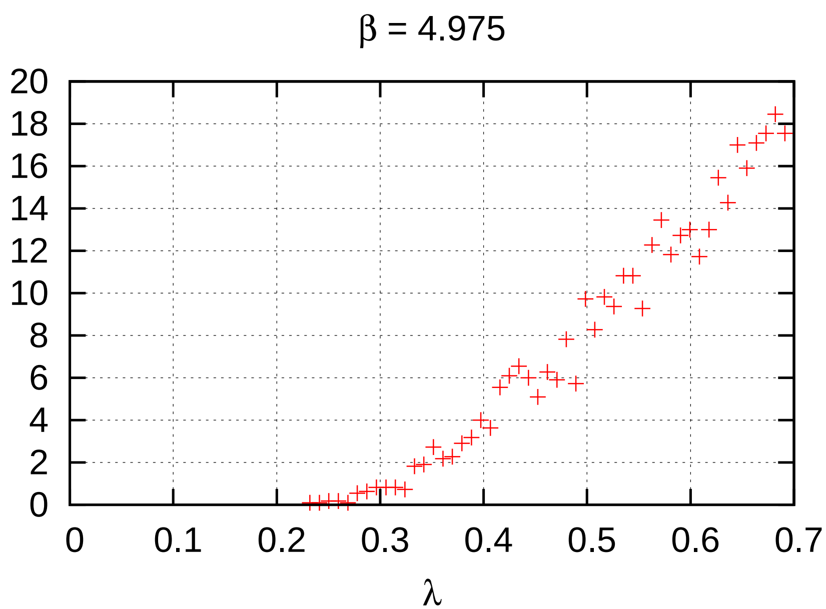
What β? Nothing so far in literature, need to start from scratch.

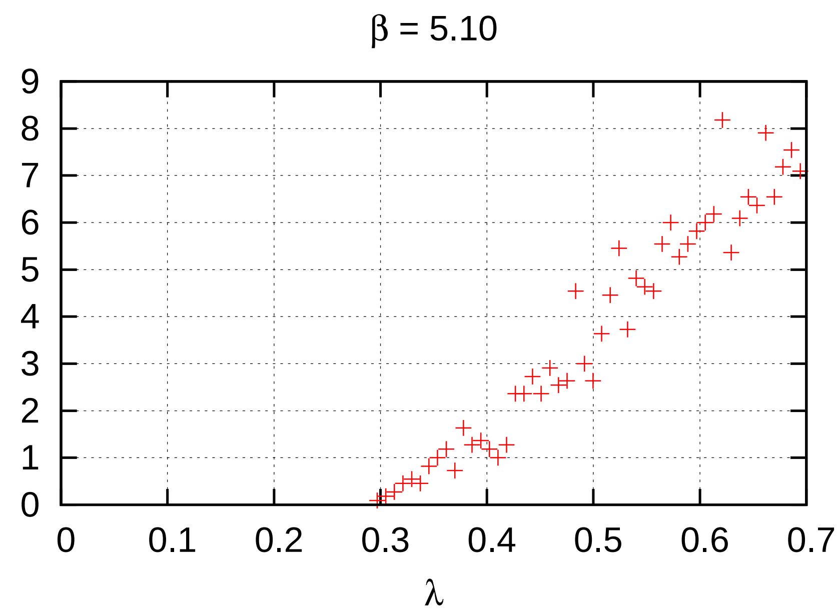
Scan $strong\ \ coupling \sim 4.5 < \beta < 5.5 \sim free$

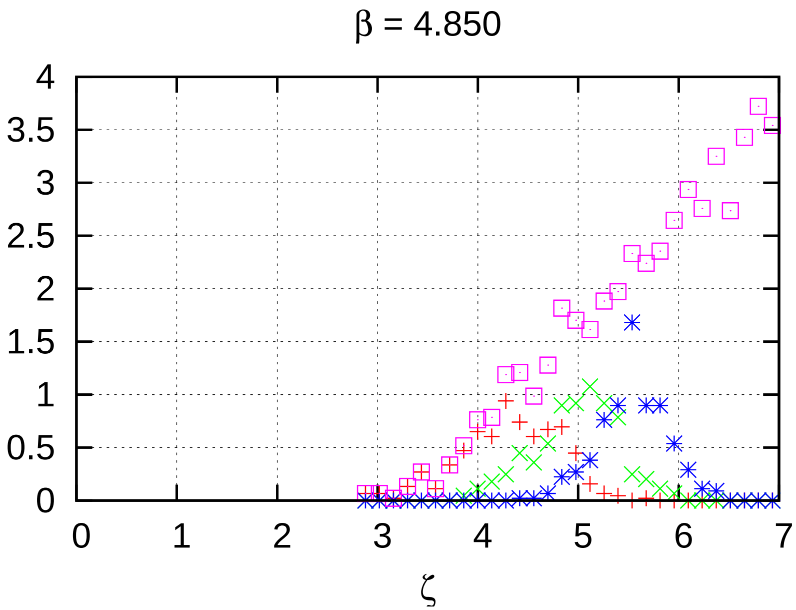
For RMT one needs $m < \lambda_1$ to see dynamical fermions

Macroscopic spectral density





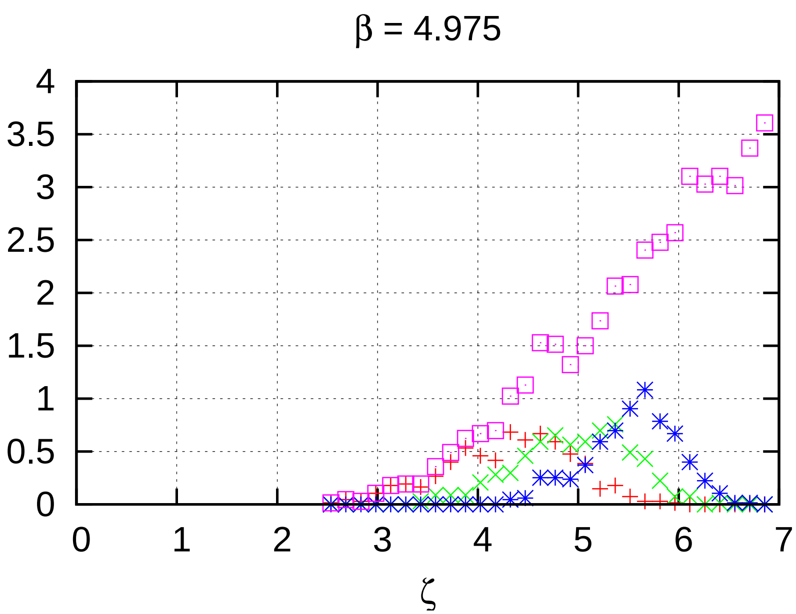


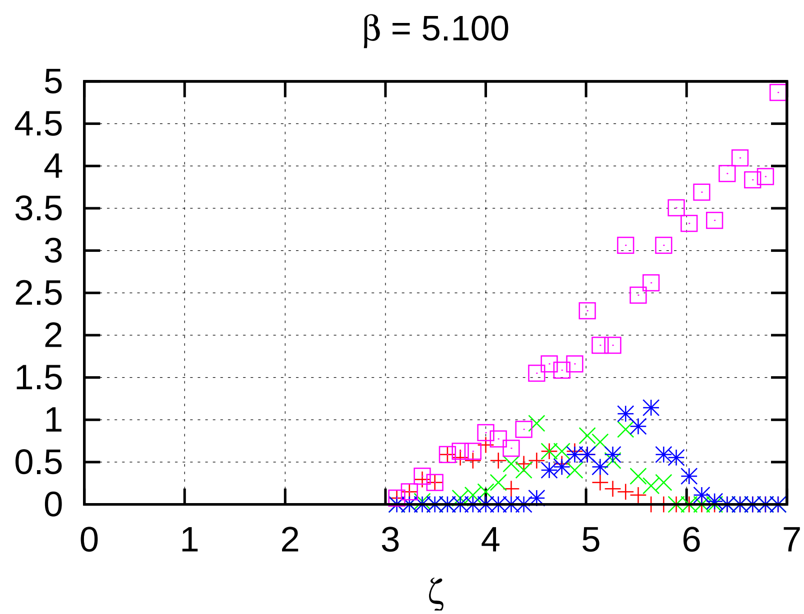


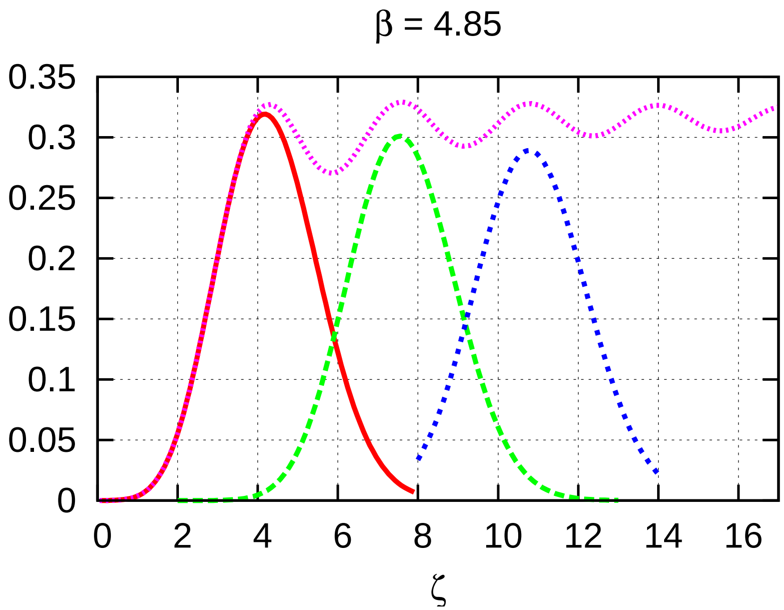
Microscopic

spectral density

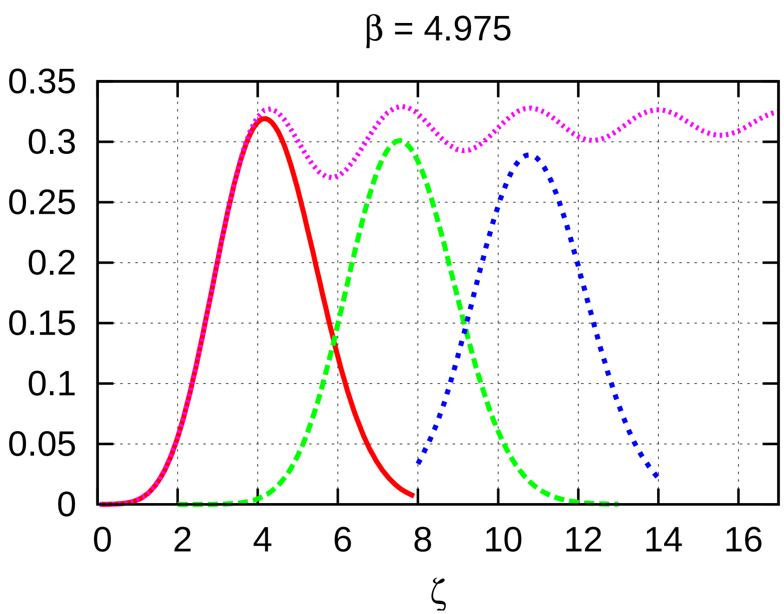
$$\Sigma(4.850) = 0.083(4)$$
$$\Sigma(4.975) = 0.084(4)$$
$$\Sigma(5.100) = 0.080(4)$$

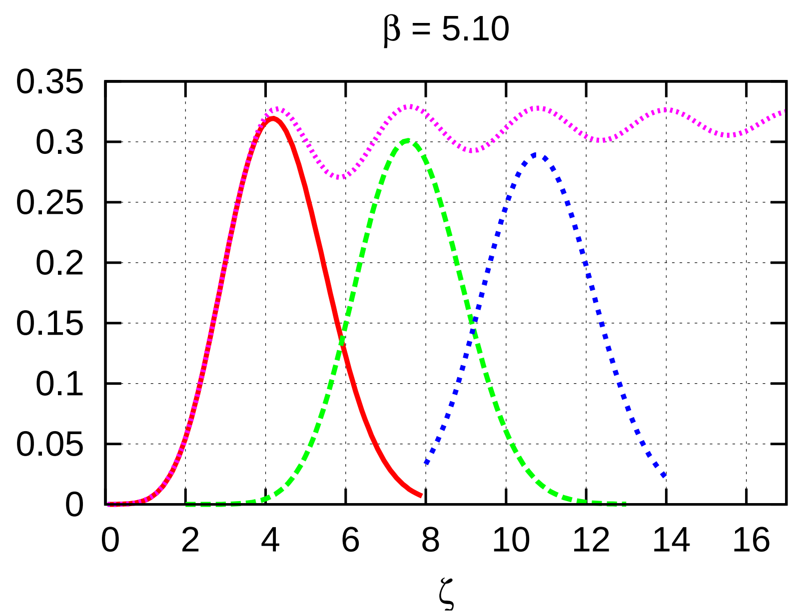






Microscopic spectral density from RMT





All our results are preliminary

2S representation seems not consistent with χSB

Reason can be too small volume, not really ε-regime

Caution! Have not measured any quantity $f_\pi, m_\pi, \ldots$

Conformal? More work needed!

Conclusion

First dynamical overlap simulation of 2S repr of SU(3)

If below conformal window: can predict narrow heavy Higgs particle without free parameters consistent with EW precision (S-parameter)

Measuring β-function will help, $\gamma(g)$.