Symmetry breaking on the lattice

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Motivations

Is Technicolor dead?

- Large oblique corrections, based on rescaled QCD
  Fahri & Susskind 74, $N_c = 2$, $N_f = 8$, $F_\pi = 246\text{GeV}$
  $$\hat{S} \sim 7 \times 10^{-3}$$

- Large FCNCs

- Extra light pions

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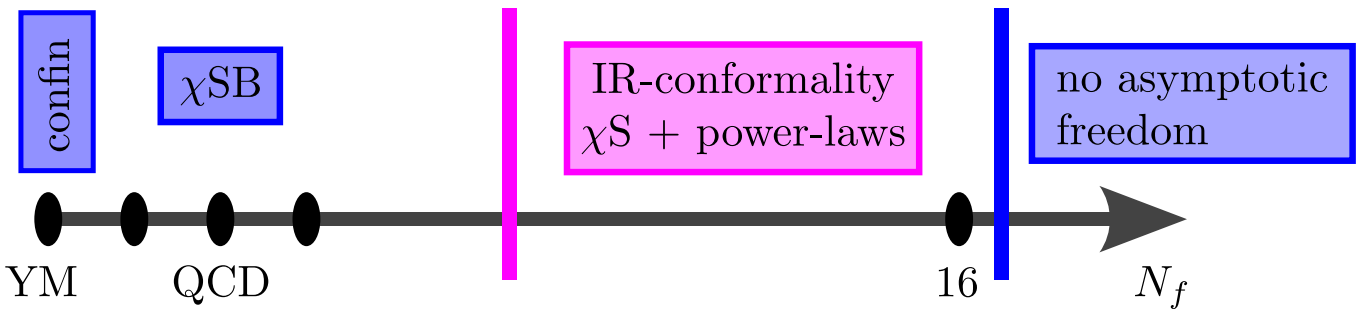

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  Seriously, we can do better than this...

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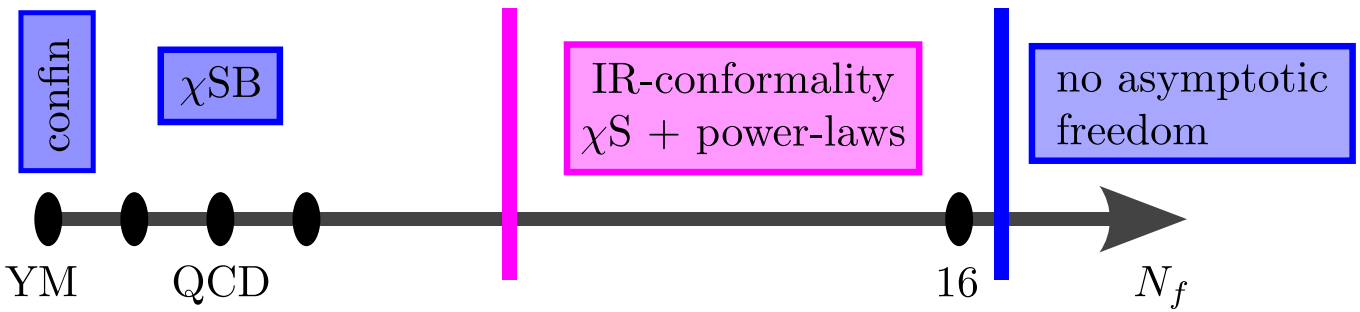
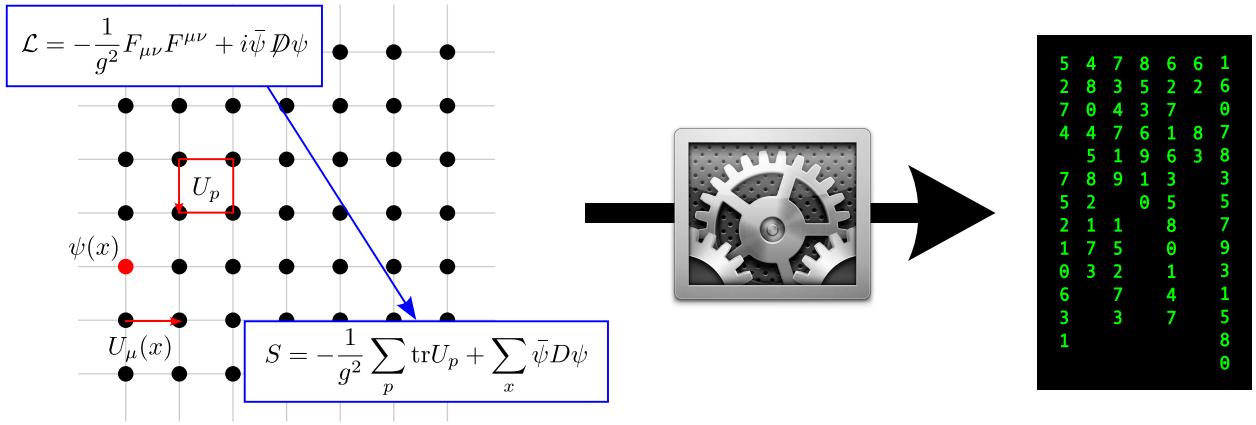


Lattice simulations



There are **approximations** involved. Limits have to be taken.

1. Discretize the space-time as a lattice.
2. Put your theory in a finite box.

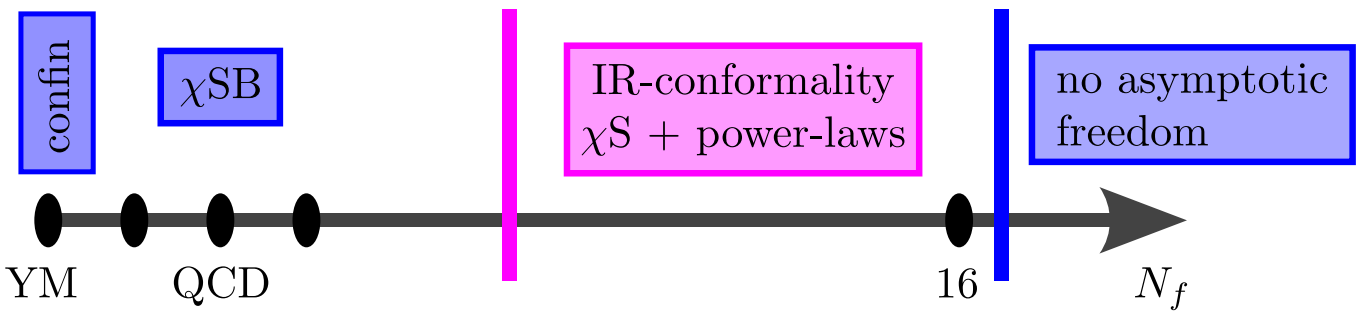
These approximations are **controllable**.

You can measure masses, dacay constants, S-parameter, running coupling, mass anomalous dimensions, phase structure...

The name of the game

Look for theories that do not bahave like rescaled QCD

Devlop intuition

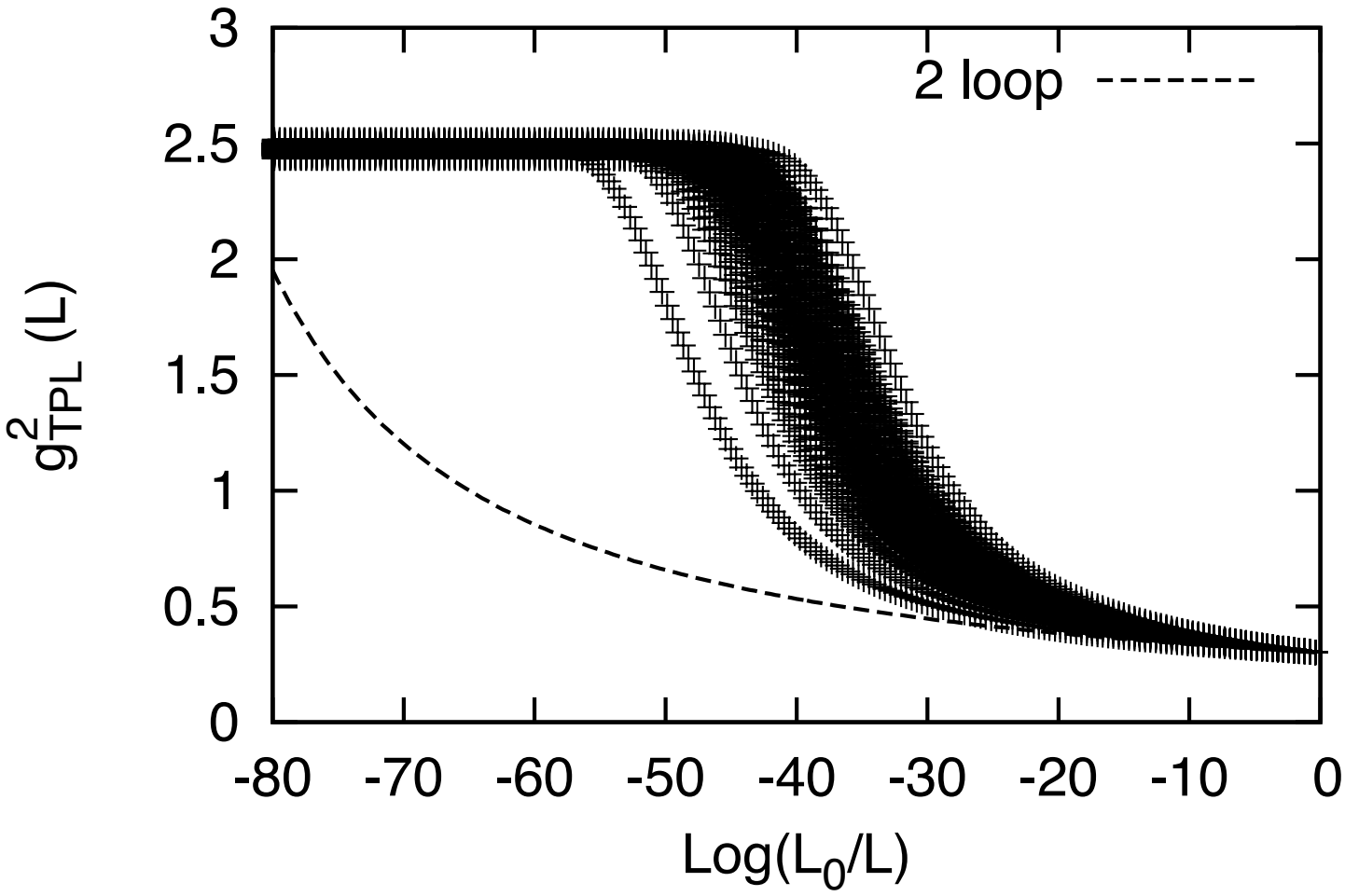


Theories under scrutiny

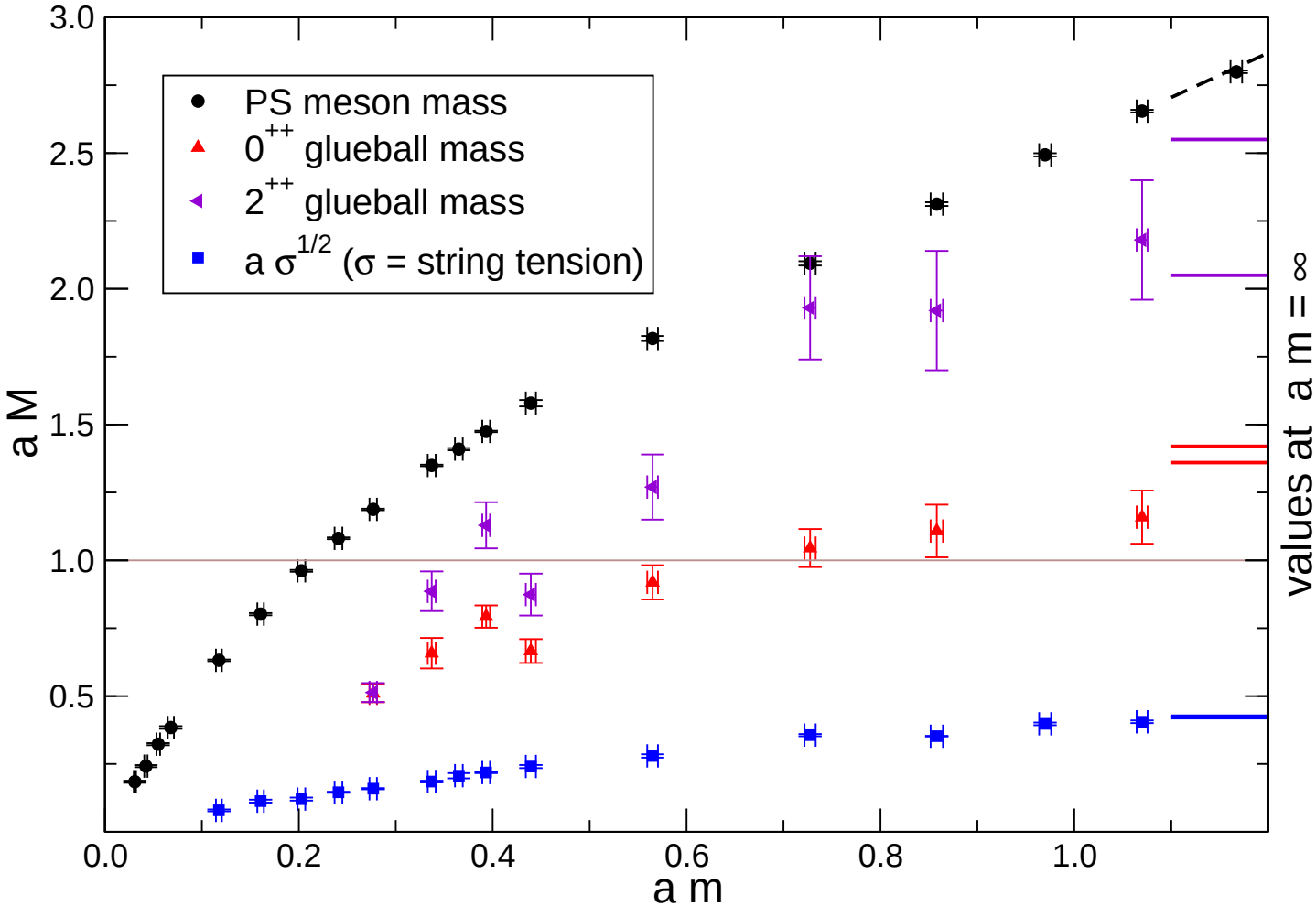
SU(3) 6f	LSD Pallante&al
SU(3) 8f	LSD Pallante&al Fodor&al Hasenfratz
SU(3) 10f	LSD Hayakawa&al
SU(3) 12f	LSD Pallante&al Fodor&al Aoyama&al Hasenfratz
SU(3) 16f	LSD Fodor&al Hasenfratz
SU(2) 2f	Lewis&al
SU(2) 6f	Bursa&al
SU(2) 8f	Aoyama&al
SU(2) 2s	DelDebbio&al Hietanen&al Catteral&al DeGrand&al
SU(3) 2s	Fodor&al DeGrand&al Kogut&al
SU(4) 2s	DeGrand&al

Red: Confining
Blue: IR-conformal
Magenta: Signals of slow running, but no sign of confinement
Black: Preliminary, no conclusions available

Running coupling for SU(3) with 12 quarks



Spectrum for SU(2) with 2 adjoint quarks



These theories are quite different from QCD!

- Light scalar isosinglet ($M_\rho/M_\sigma \sim 2$ vs. 1.3)
- Small splitting between the axial and vector isotriplet mesons($M_{a_1}/M_\rho \sim 1.2$ vs. 1.6)
- Small slope for the Regge trajectory ($M_\rho/\sqrt{\sigma} \sim 8$ vs. 1.8)
- Reduction of the S-parameter (easily a factor of 3)

After 5 years, we are at the beginning...

IBM BG/P in LLNL (US)

IBM BlueGene/P in Swansea (UK): 2048 quad-core processors with high-speed connection

I will be running for 3 months for a point on a plot. This is a limitation and a challenge: we need to get smarter

arXiv hep-lat: 1.58 papers per diem; hep-ph: 12.7 papers per diem

Messages to take home

- Lattice simulations are a unique tool for studying nonperturbative gauge theories from first principles. They are being successfully used for QCD, and they can be used successfully for other theories.
- As you start playing with the number of flavours and the quark representation, you get physics that is very different from rescaled QCD. We understand theories in the conformal window better than 5 years ago, we have to do more work towards walking or more realistic models.
- Lattice simulations take time (years...).