Hunting for the conformal window

Agostino Patella

Lattice Gauge Theory group
Room 4-2.032

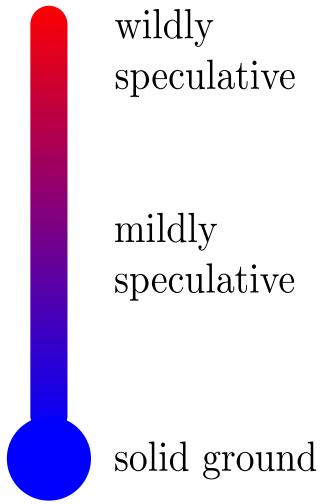
November 4th, 2010

Conformal window

$$\mathcal{L} = -\frac{1}{2g^2}\,\mathrm{tr}\,F^2 + i\bar{\psi}\,\not{D}\,\psi$$

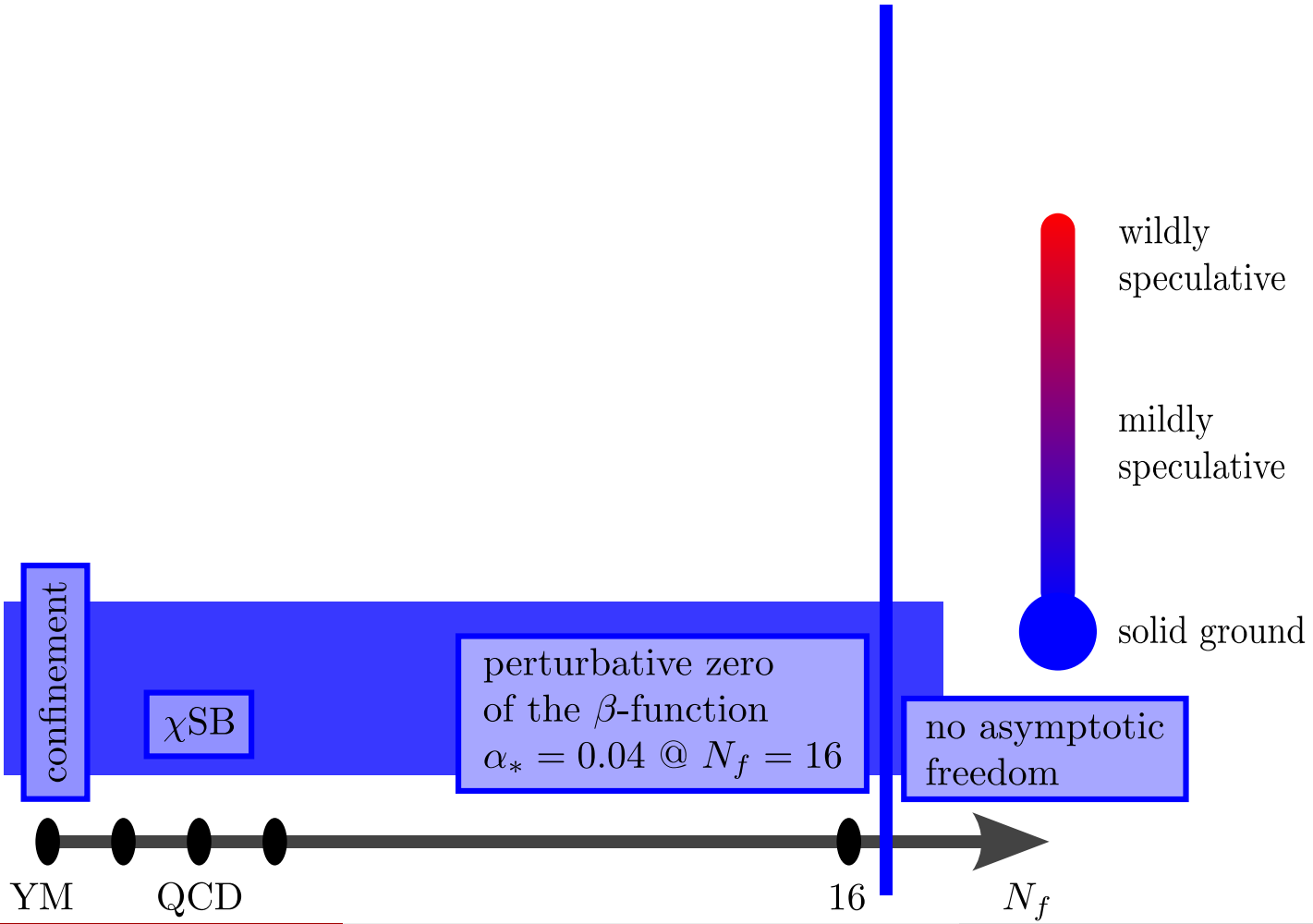
Conformal window

$$\mathcal{L} = -\frac{1}{2g^2}\,\mathrm{tr}\,F^2 + i\bar{\psi}\,\not{D}\,\psi$$



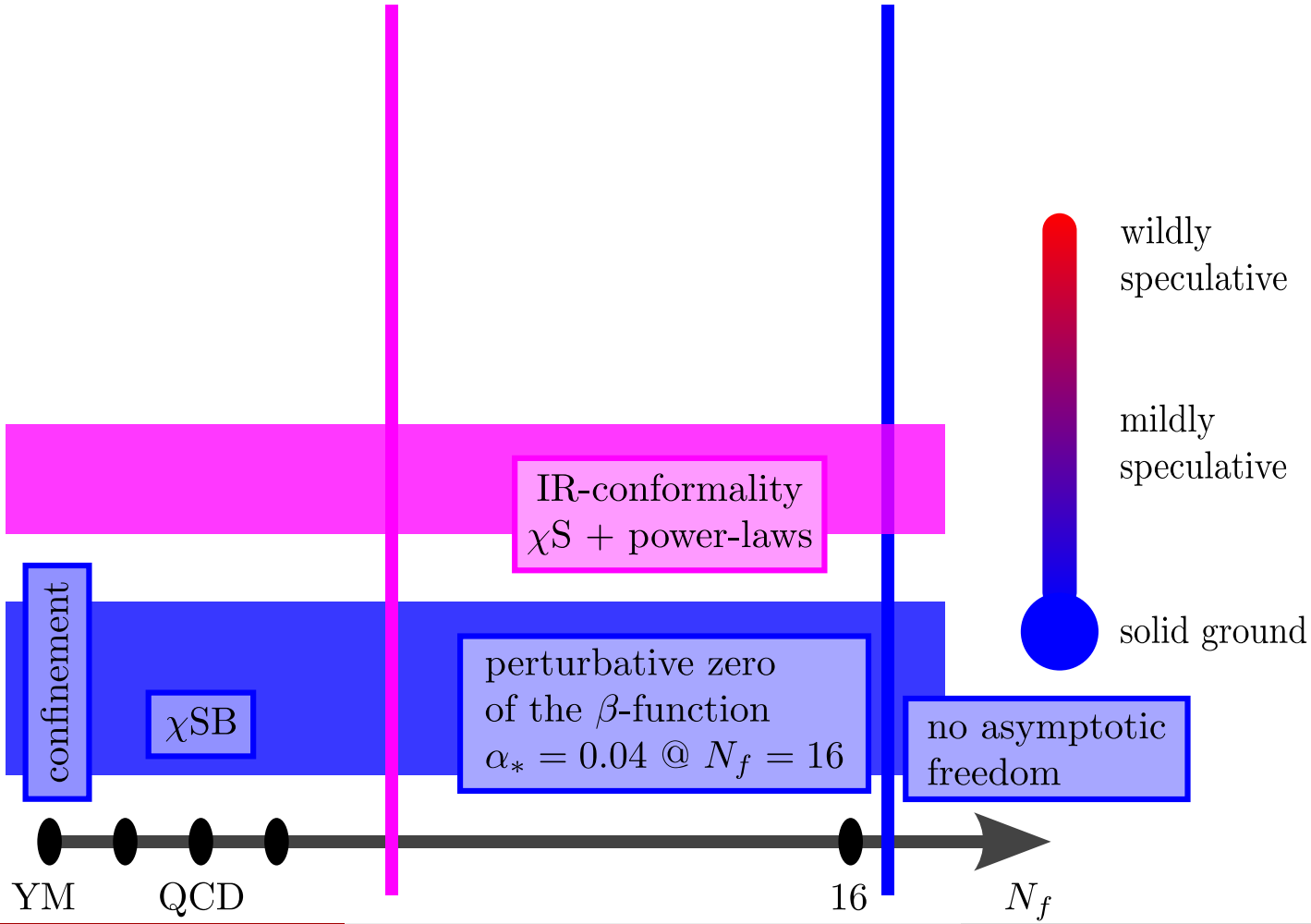
Conformal window

$$\mathcal{L} = -\frac{1}{2g^2}\,\mathrm{tr}\,F^2 + i\bar{\psi}\,\not{D}\,\psi$$



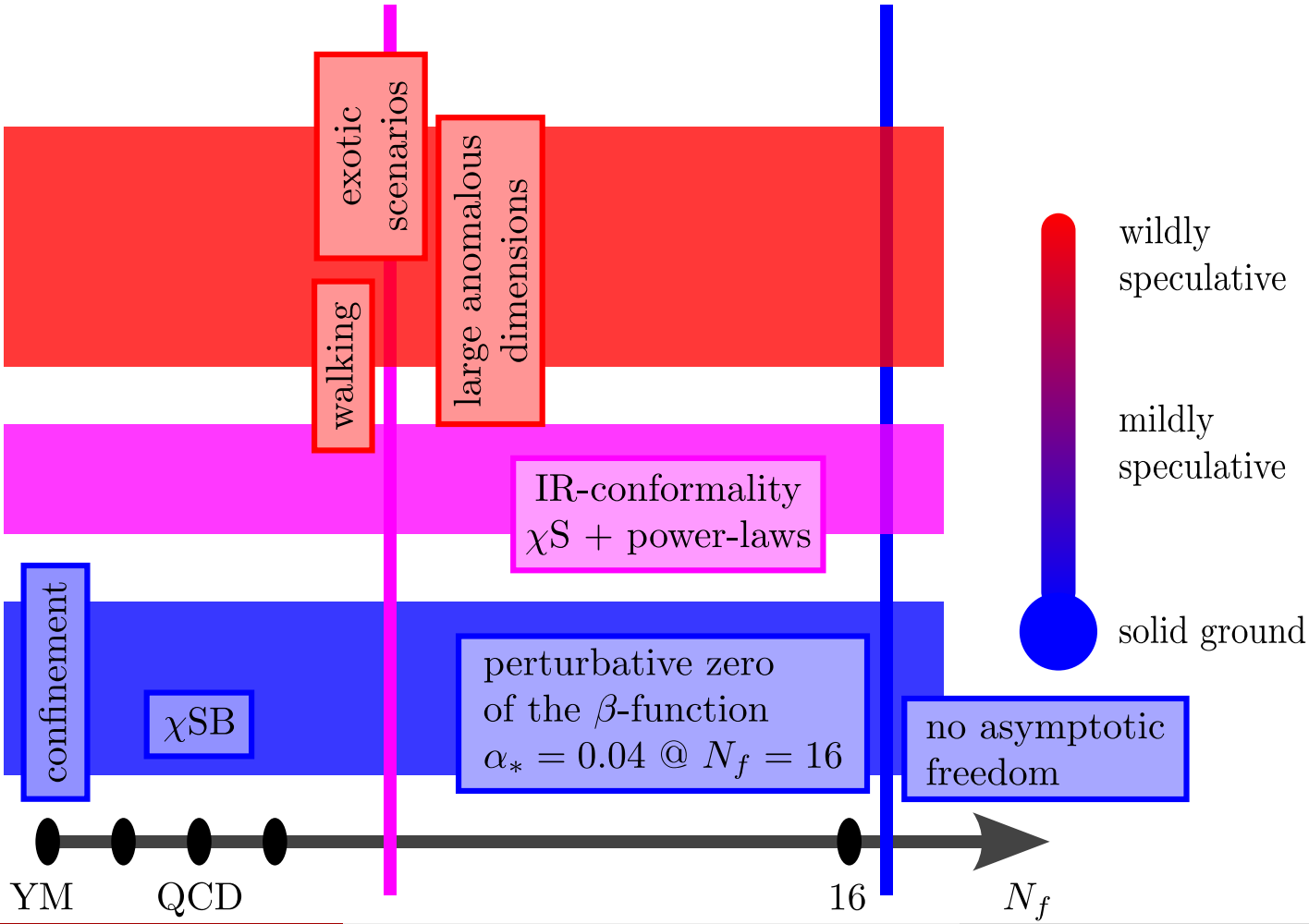
Conformal window

$$\mathcal{L} = -\frac{1}{2g^2}\,\mathrm{tr}\,F^2 + i\bar{\psi}\,\not{D}\,\psi$$



Conformal window

$$\mathcal{L} = -\frac{1}{2g^2}\,\mathrm{tr}\,F^2 + i\bar{\psi}\,\not{D}\,\psi$$



Gauge theories with many fundamental fermions or fermions in higher representations

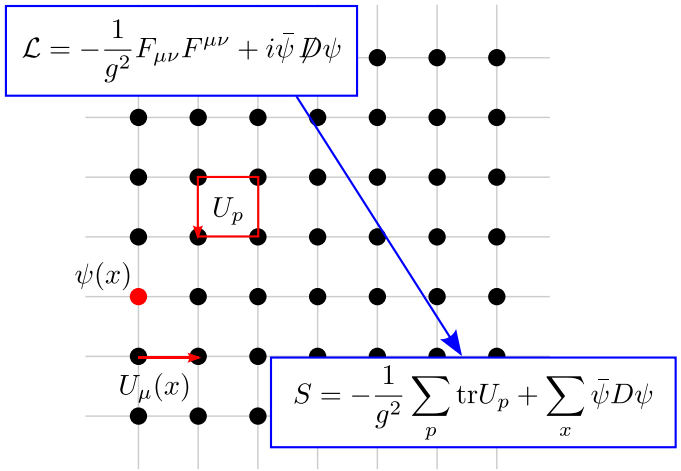
- We have a limited knowledge of non-supersymmetric gauge theories in the nonperturbative regime (YM and QCD)

Gauge theories with many fundamental fermions or fermions in higher representations

- We have a limited knowledge of non-supersymmetric gauge theories in the nonperturbative regime (YM and QCD)
- Numerical simulations of the lattice-discretized theories

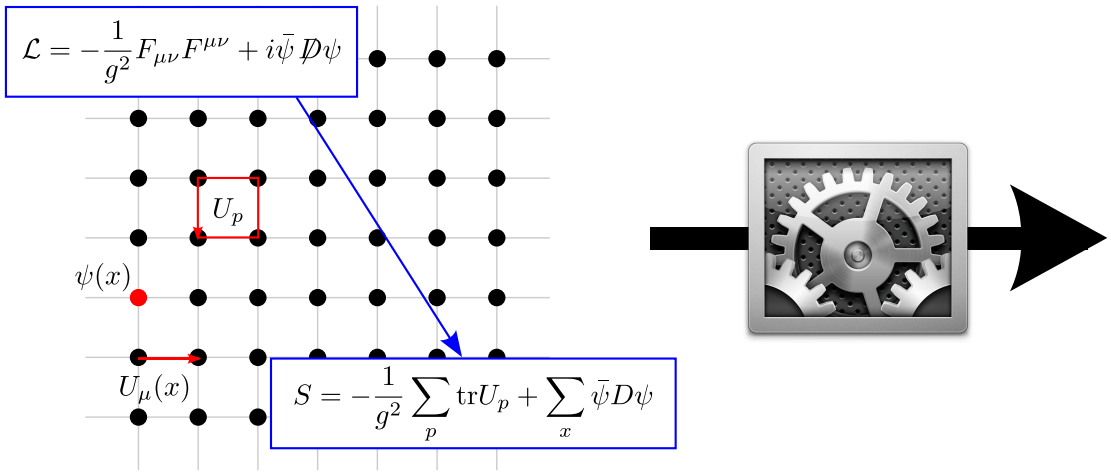
Gauge theories with many fundamental fermions or fermions in higher representations

- We have a limited knowledge of non-supersymmetric gauge theories in the nonperturbative regime (YM and QCD)
- Numerical simulations of the lattice-discretized theories



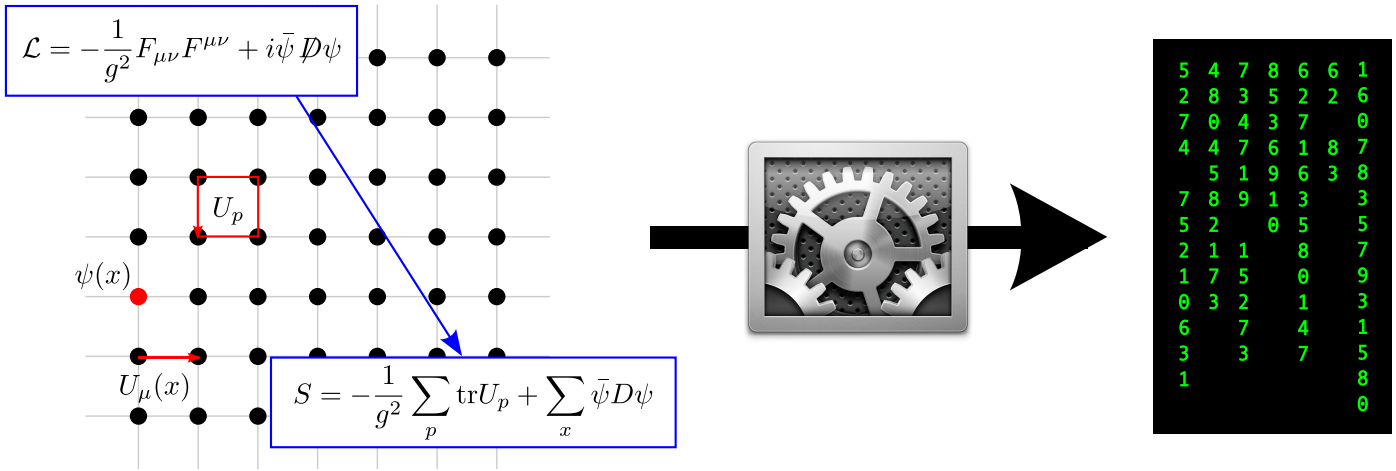
Gauge theories with many fundamental fermions or fermions in higher representations

- We have a limited knowledge of non-supersymmetric gauge theories in the nonperturbative regime (YM and QCD)
- Numerical simulations of the lattice-discretized theories



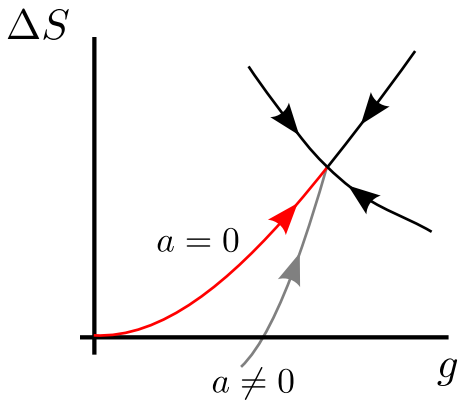
Gauge theories with many fundamental fermions or fermions in higher representations

- We have a limited knowledge of non-supersymmetric gauge theories in the nonperturbative regime (YM and QCD)
- Numerical simulations of the lattice-discretized theories



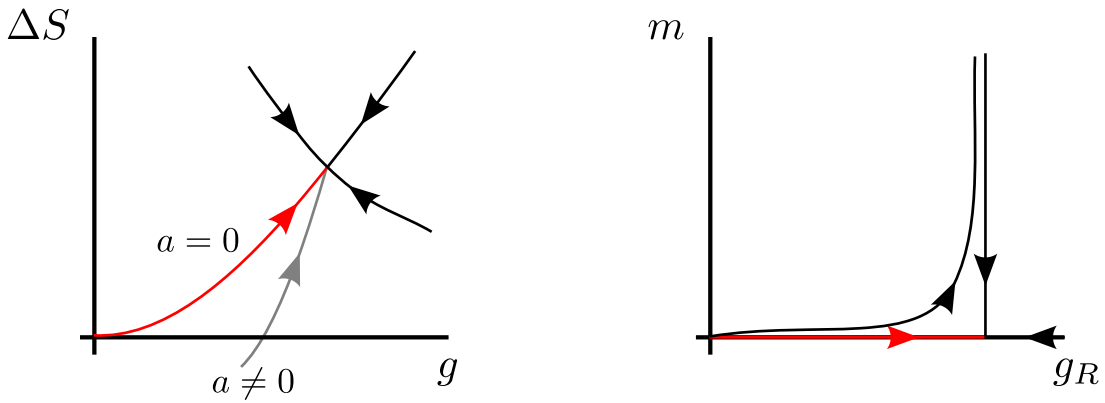
- Analytical understanding in order to interpret the results and guide the simulations (no experimental data here!)

Investigating the conformal window



- Scale invariance is broken in all possible ways on the lattice. Develop (or import e.g. from the theory of *critical phenomena*) tools for identifing remnants of scale invariance.

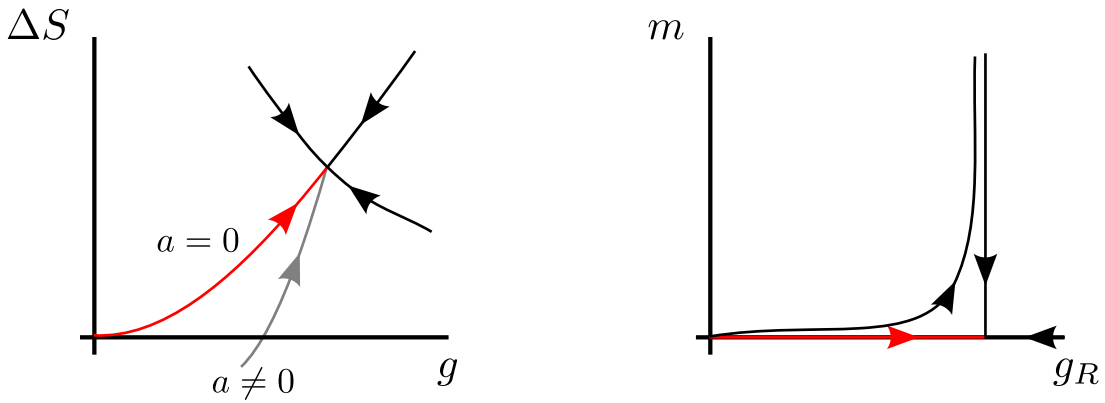
Investigating the conformal window



- Scale invariance is broken in all possible ways on the lattice. Develop (or import e.g. from the theory of *critical phenomena*) tools for identifing remnants of scale invariance.

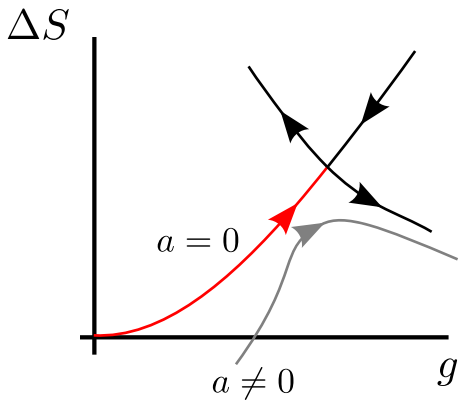
- How does a mass-deformed IR-conformal gauge theory look like?
  - Mass-gap and confinement
  - **Scaling:** For *small enough* fermionic mass: $M \propto m_q^{\eta}$
  - What is *small enough*?

Investigating the conformal window



- Scale invariance is broken in all possible ways on the lattice. Develop (or import e.g. from the theory of *critical phenomena*) tools for identifing remnants of scale invariance.
- How does a mass-deformed IR-conformal gauge theory look like?
- How does an IR-conformal gauge theory look like in a finite box?
  - Mass-gap and deconfinement
  - **Scaling:** For *large enough* volumes: $M \propto 1/L$
  - What is *large enough*?

Investigating the conformal window



- Scale invariance is broken in all possible ways on the lattice. Develop (or import e.g. from the theory of *critical phenomena*) tools for identifing remnants of scale invariance.
- How does a mass-deformed IR-conformal gauge theory look like?
- How does an IR-conformal gauge theory look like in a finite box?
- Strongly-coupled IR-conformal gauge theories? Large anomalous dimensions? Finite lattice spacing will switch on extra relevant directions. *Hic sunt leones.*

Investigating the conformal window

- Scale invariance is broken in all possible ways on the lattice. Develop (or import e.g. from the theory of *critical phenomena*) tools for identifing remnants of scale invariance.
- How does a mass-deformed IR-conformal gauge theory look like?
- How does an IR-conformal gauge theory look like in a finite box?
- Strongly-coupled IR-conformal gauge theories? Large anomalous dimensions? Finite lattice spacing will switch on extra relevant directions. *Hic sunt leones.*
- Completely different methods: running of the renormalized coupling (e.g. SF scheme), analysis of the Wilsonian renormalization group. We need some smart idea here...

Looking for chirally broken, non QCD-like physics

- Gauge theories *right outside* of the conformal window are expected to be very different from QCD

Looking for chirally broken, non QCD-like physics

- Gauge theories *right outside* of the conformal window are expected to be very different from QCD
- Is there a way to define walking in a RG-invariant (i.e. meaningful) way?

Looking for chirally broken, non QCD-like physics

- Gauge theories *right outside* of the conformal window are expected to be very different from QCD
- Is there a way to define walking in a RG-invariant (i.e. meaningful) way?
- Can any of those theories be relevant (if not directly, at least in a pedagogical sense) for BSM physics?

Few words before questions...

- Exploring the conformal window for non SUSY gauge theories is very challenging. It is an interesesting problem from a purely QFT point of view. It might turn to be useful for BSM physics.
- Although numerical simulations on the lattice can be used, analytical knowledge is usually required as a guidance.
- In the past I've found profitable to talk to AdS/CFT people, phenomenologists, field theorists. Looking for people in different fields interested to the same or similar problems.
- Other main interests:
  • Large-N limit of pure Yang-Mills and theories with fermions in the two-index representations.
  • Large-N equivalences (orientifold planar equivalence, volume reduction, ...)