Walking Technicolor on the Lattice

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Edinburgh
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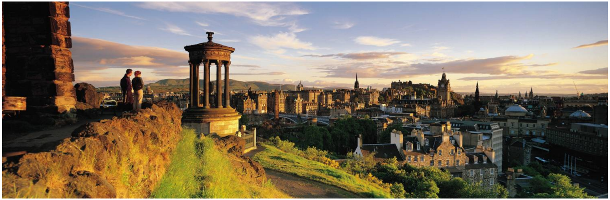
Introduction



Technicolor : Problems and solutions

Lattice : Measuring scale-dependence

Results : (Very) preliminary

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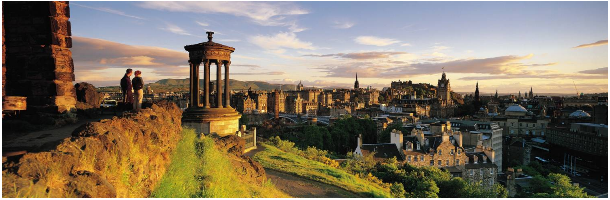

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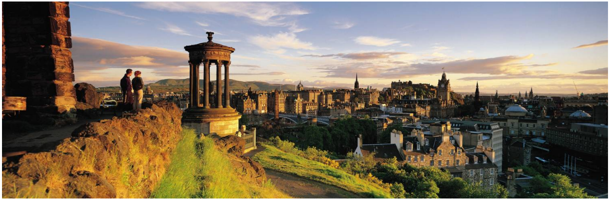

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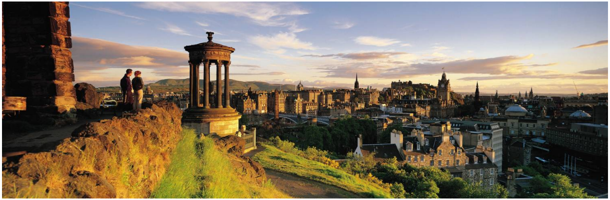

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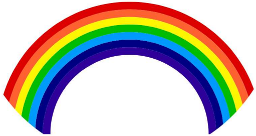

Technicolor replaces the Higgs mechanism with a strongly coupled gauge theory of techni-quarks. There are two scales involved:

Λ_{TC} : Techni-quark condensate breaks the electroweak sector

Λ_{ETC} : Techni-quarks interact with SM quarks to give them mass

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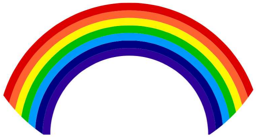

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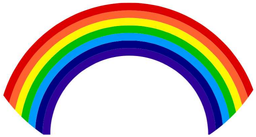

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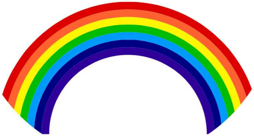
Technicolor Problems

If we assume the strong coupling dynamics are a scaled up version of QCD, this leads to problems:



Flavour Changing Neutral Currents

- Need Λ_{ETC} to be big

Quark Masses

- Need Λ_{ETC} to be small

EW Precision Data

- Conflicts with data

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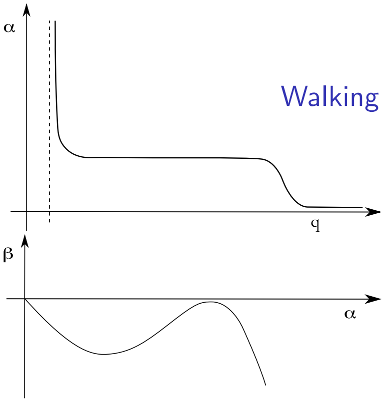
Solution

Walking Coupling : Relaxes upper bound on Λ_{ETC}

Small N_f : Improves EW problems

So we want a walking coupling, with anomalous dimension $\gamma_m \sim 1$, and a small number of flavours

Solution



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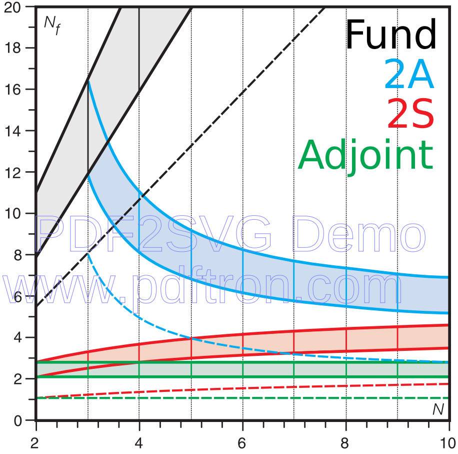
Fund
2A
2S
Adjoint
N_f
N
20
18
16
14
12
10
8
6
4
2
0
2
4
6
8
10

Goal

- Investigate Minimal Walking Technicolor
- This a gauge theory with two flavours of Techni-fermions which transform under the SU(2) Adjoint representation of the gauge group.
- Want to measure the anomalous dimension γ_m, and the running of the coupling $\overline{g}^2(\mu)$ and mass $\overline{m}(\mu)$ over a range of scales μ.

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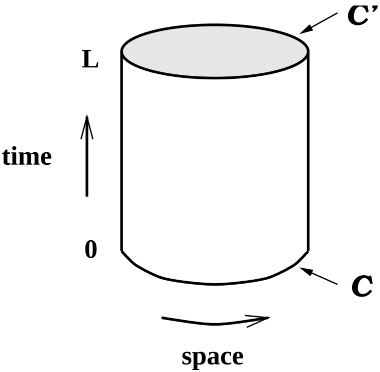
Schrodinger Functional



(LxLxL box with periodic b.c.)

- Use Schrodinger Functional - a finite volume renormalisation scheme
- Only one scale, L, so coupling runs with it: $\overline{g}^2(L)$.

Changing the Scale

We can change two things:

- L/a, the number of points on one side of our lattice
- a, the physical length between these points

Ideally would pick some initial a and L/a, and measure observables at the scale L, then double the number of points and measure at the scale $2L$, double again for $4L$, etc. The energy scale $\mu \propto 1/L$

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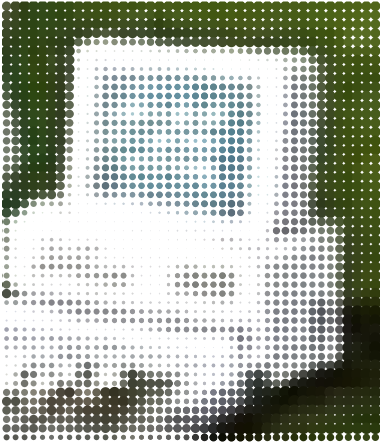
A single step



- We pick a resolution ($L/a = 10$), and lattice spacing (a), and measure our observables at this scale L.
- Now we keep the same a but double the number of points to 20, and measure the observables at the scale $2L$

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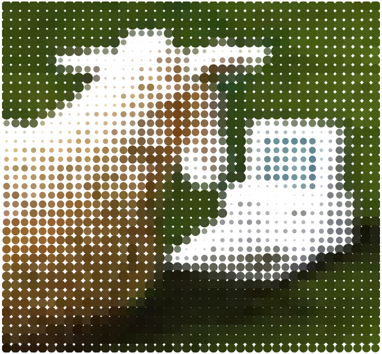

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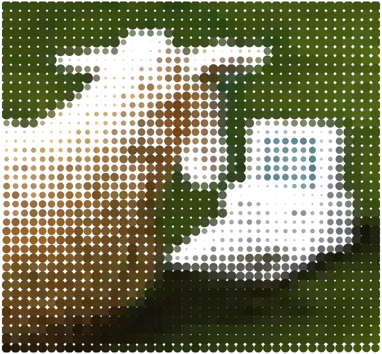

- We adjust a so that our lattice with 10 points is now at the scale $2L$. Essentially we are looking at the same scale, but at half the resolution, or number of points.
- Now we can go from 10 to 20 points again, and be at the scale $4L$

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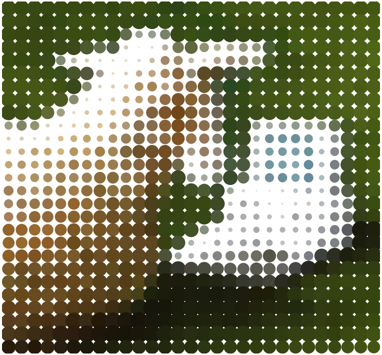

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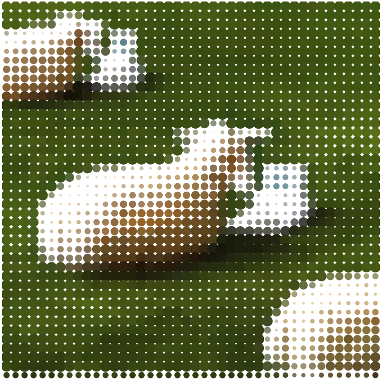

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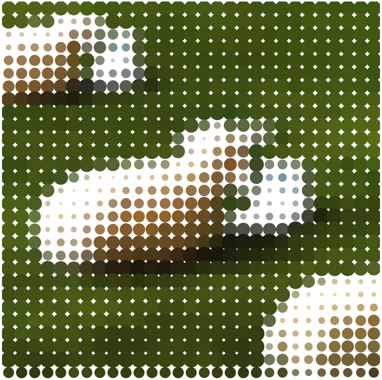

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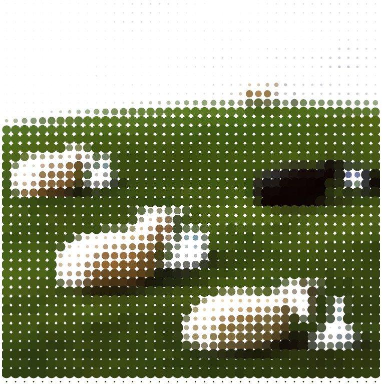

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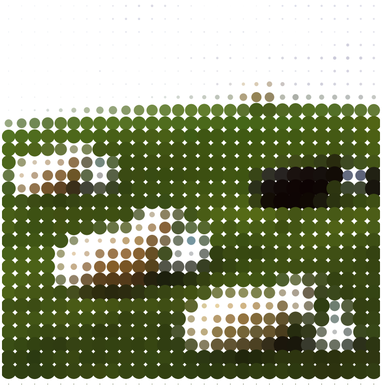

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Continuum Extrapolation

- Notice the resolution wasn't very good, and got worse at each step
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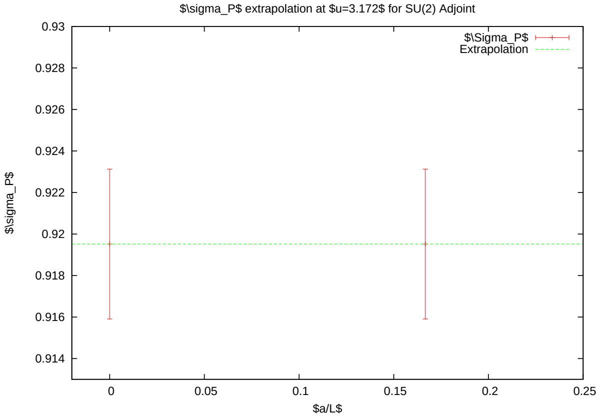
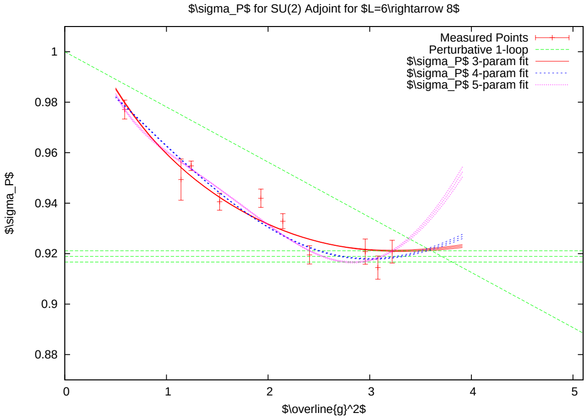
Continuum Extrapolation of σ_P



$$\Sigma_P(\mu, L/a) = \frac{\overline{m}(\mu)}{\overline{m}(\mu/2)}$$

$$\sigma_P(\mu, L/a) = \lim_{a \to 0} \Sigma_P$$

Anomalous Dimension



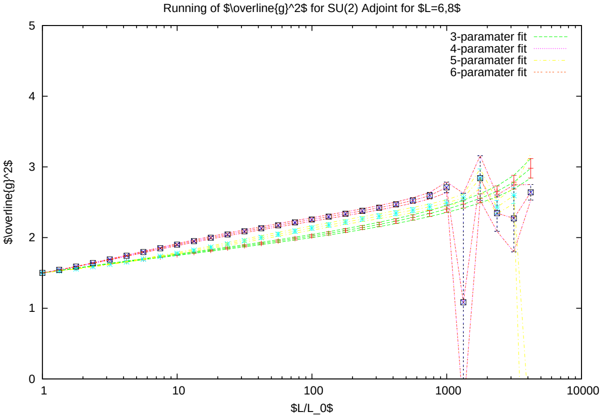
For large $\overline{g}^2$:

$$\overline{m} \sim \mu^{\tau}$$

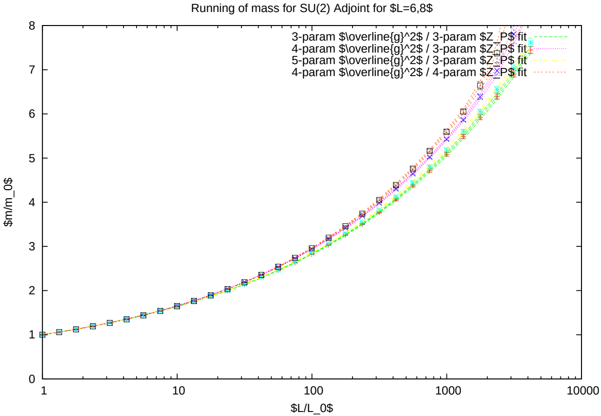
$$\sigma_P = \frac{\overline{m}(\mu)}{\overline{m}(\mu/2)} = 2^{\tau}$$

$$\tau = 0.286(8)$$

Running Coupling



Running Mass

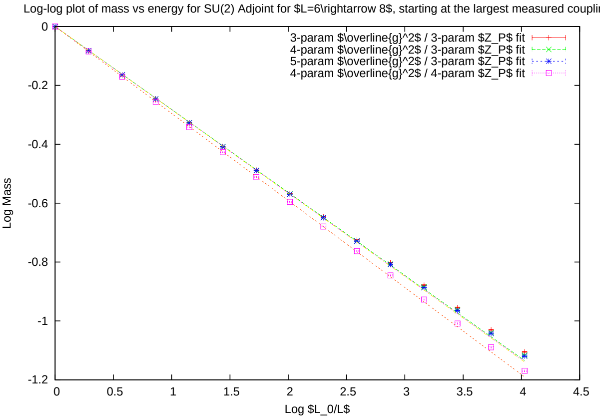


Anomalous Dimension

In the IR limit, if the renormalised mass does indeed have the form $m \sim \mu^{\tau}$, then a on a log-log plot of m against μ, the points should form a straight line, the gradient of the line being the anomalous dimension:

$$\log m = -\tau \log \mu + const.$$

Anomalous Dimension



Linear fits give

$$\tau = 0.282(3)$$

Agrees well with previous determination

$$\tau = 0.286(8)$$

Conclusion

- Coupling looks like it's walking over the range of scales looked at so far.
- Anomalous mass dimension is relatively large, or at least not small: $\tau \sim 0.3$.
- But no continuum extrapolation yet, and small lattices, so this will have large discretisation errors.
- Currently simulating on larger lattices which will help with this.

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