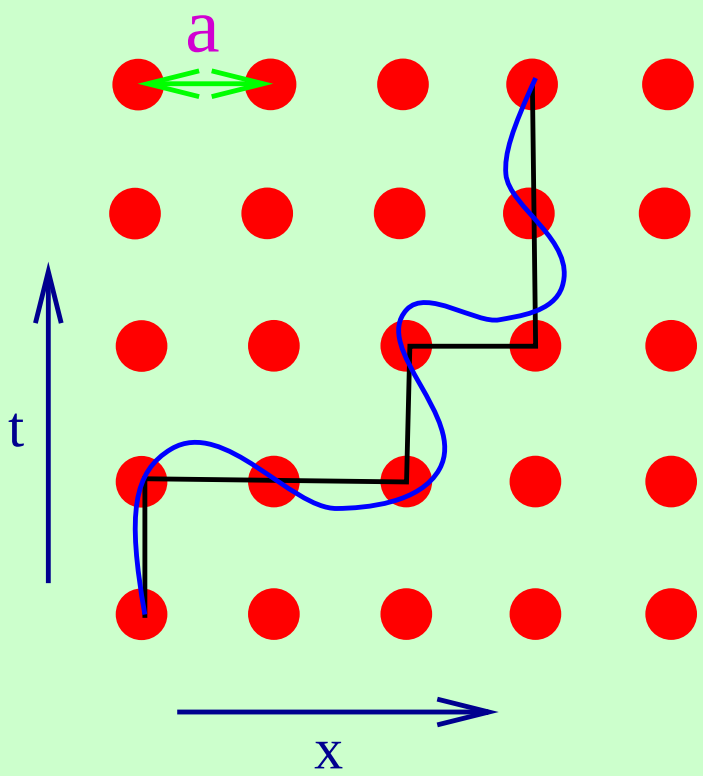
So you want to be a lattice theorist?

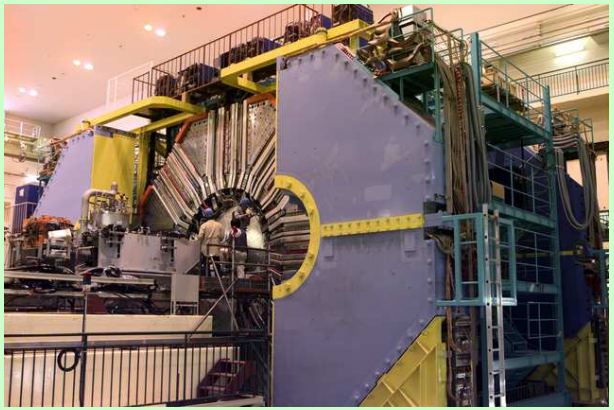
The lattice is a mathematical trick

- Quarks: hop between sites
- Over glue on bonds
- Confinement
  - mobs like to hop together

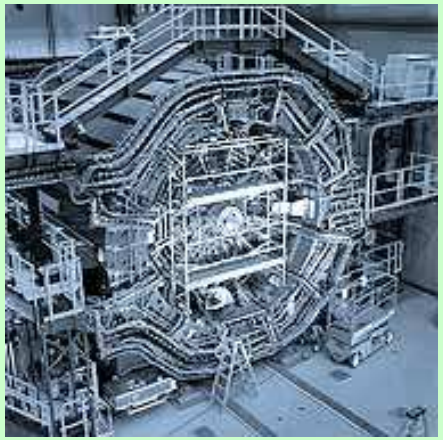


But it allows calculations

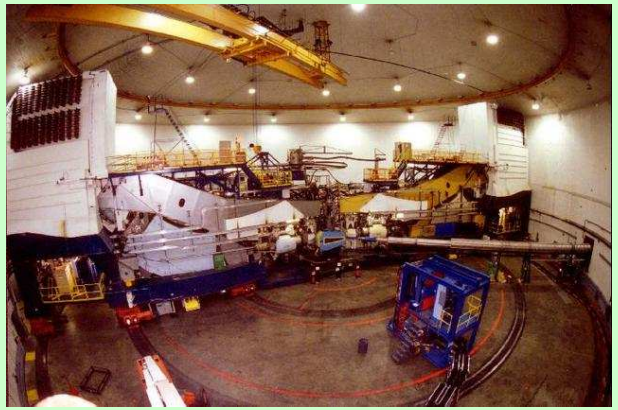
- In theories where other methods fail
  - perturbation theory
  - semiclassical methods
- Predictions have experimental implications
  - extracting weak matrix elements
  - high temperature and density (quark gluon plasma)
  - nucleon structure



BELLE



STAR



JLAB

And we get to play with big computers

It helps to start young

Keep at it through your teen years

And join the party!

Our computers are lattices

QCDOC

Made out of sublattices

QCDOC motherboard

Some lattice groups are large

Ocean City, NJ, 1933 (NY Times)

The flavors can be good

But beware of lurking tastes

There are good causes too!

Ovarian cancer awareness network

A random lattice

Anza Borrego desert

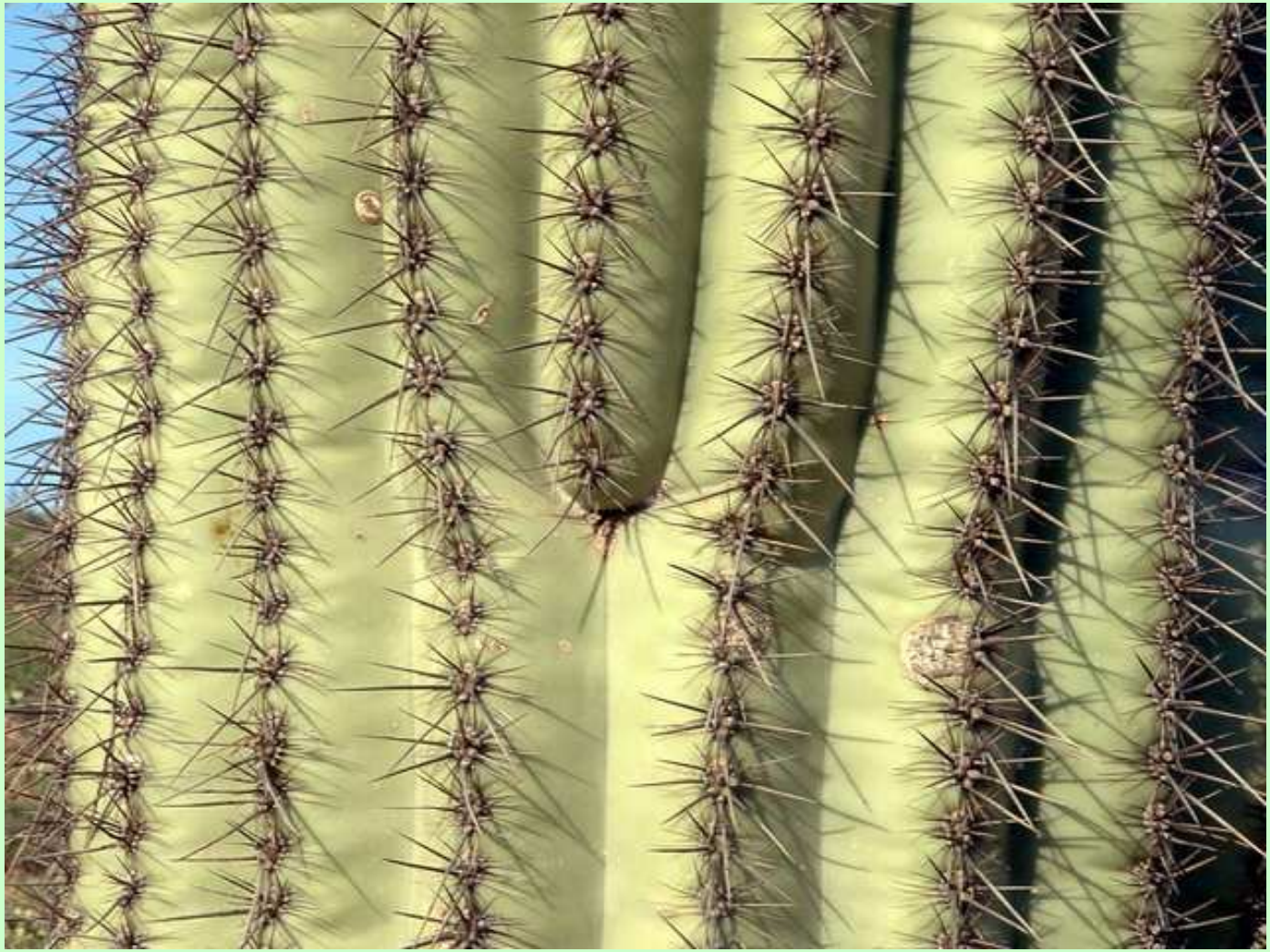
An adaptive lattice

BNL Nanocenter

Unusual lattices appear in cities

NYC

A lattice dislocation

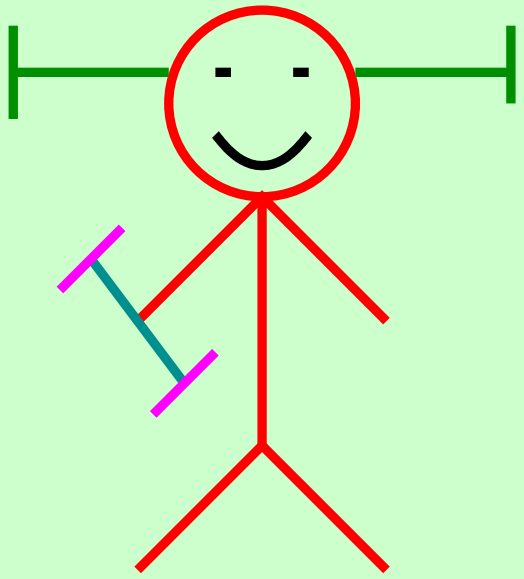


Lattice 2006

We can experiment with lattices

This gives theorists errorbars

- Statistical
  - Monte Carlo methods
- Systematic controlled:
  - finite volume
  - finite spacing
  - quark mass extrapolations
- Systematic uncontrolled:
  - valence approximation
  - flavor extrapolations (rooting)



Sometimes lattice issues get thorny

Chiral symmetry tricky

Light pions tied to light quarks

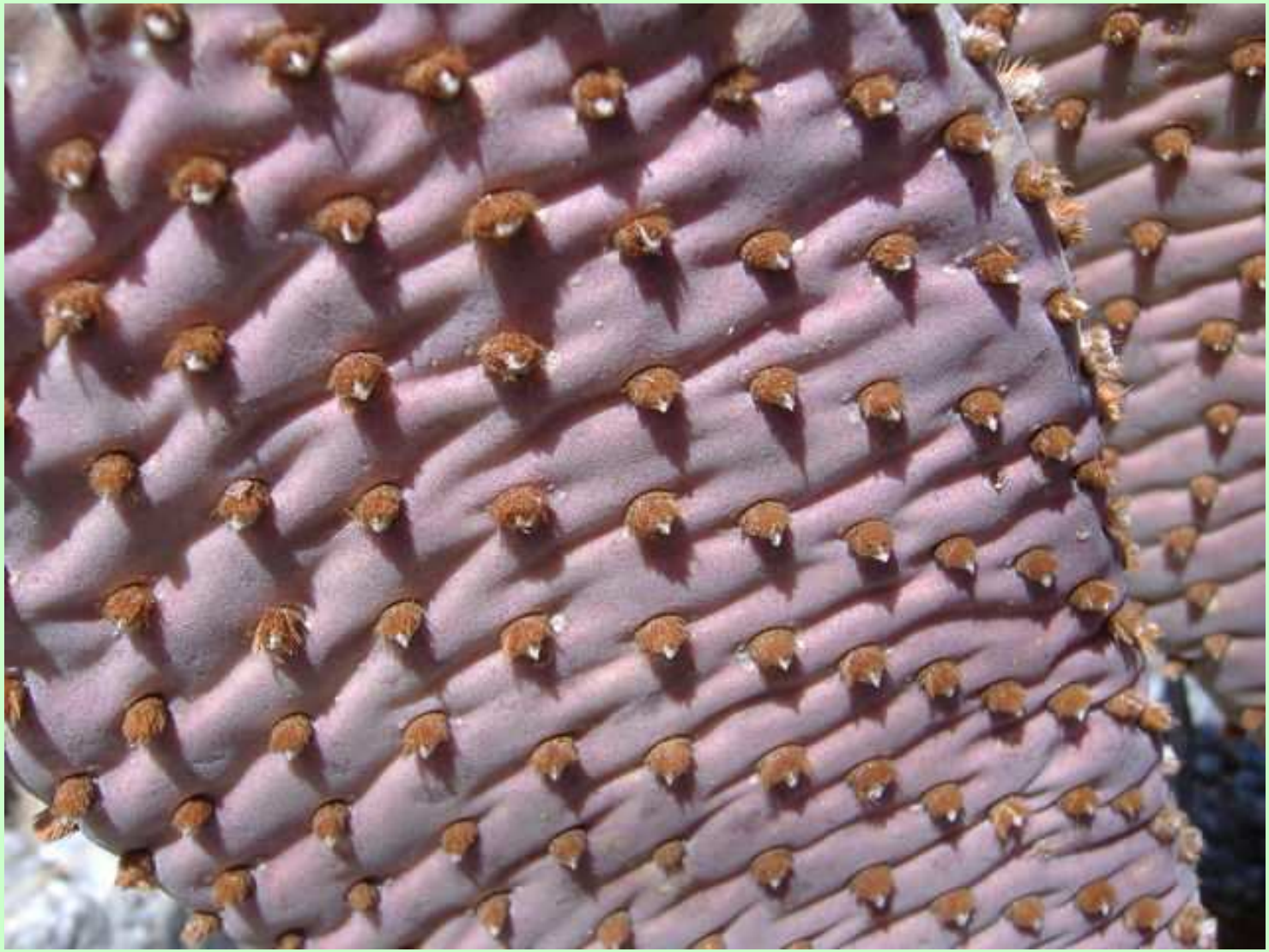
- ignoring anomalies gives doublers

Elegant approaches

- domain walls
  - use five dimensions
- Ginsparg-Wilson fermions
  - overlap operator
  - slightly non-local

Today we have a nice chiral/lattice synergy

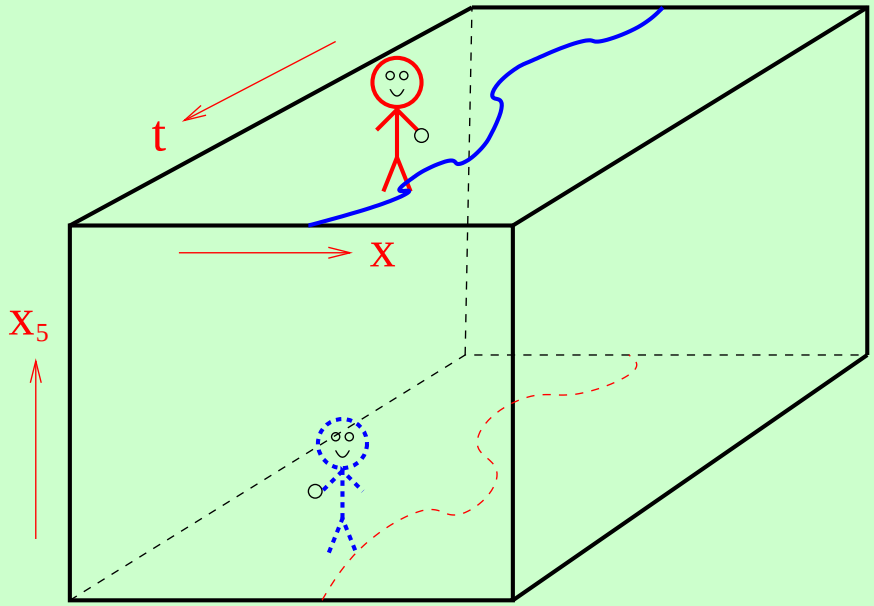
But the thorns can be subtle



No known lattice formulation for the weak interactions

Is the standard model well defined?

- neutrinos are left handed
- lattice doublers bring in right handed partners
- domain walls have anti-wall partners



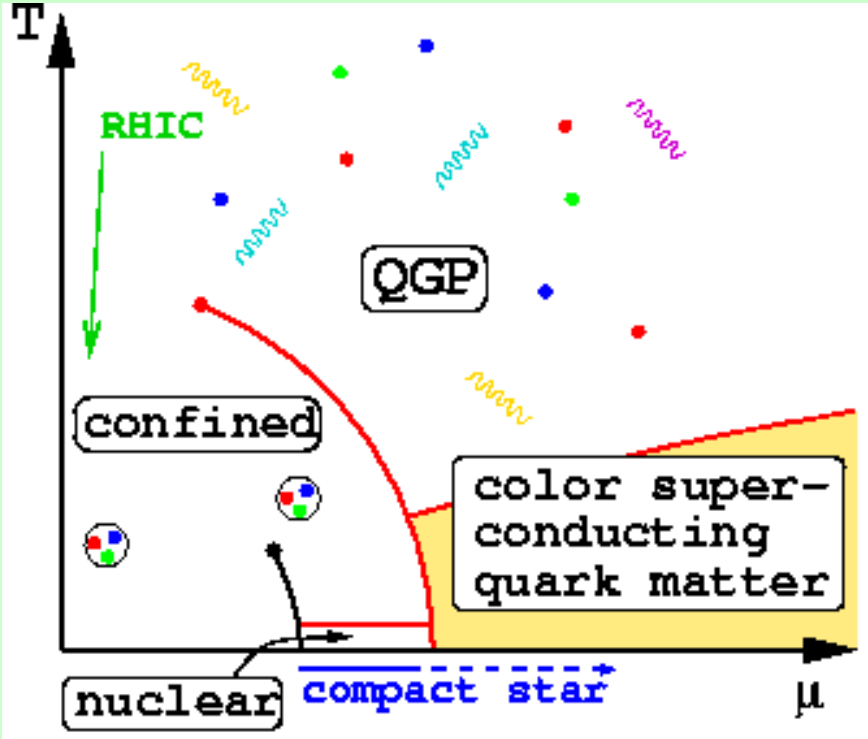
Large baryon density

No practical lattice algorithms known

- exponential in system size

Cannot explore color superconductivity

- rich phase diagram expected



Mark Alford

Some lattice ideas are controversial

Three flavor QCD

Chiral lagrangians

- predict a rich phase structure
- effective field $\Sigma \in SU(3)$
- $\Sigma \propto \overline{\psi}\psi$

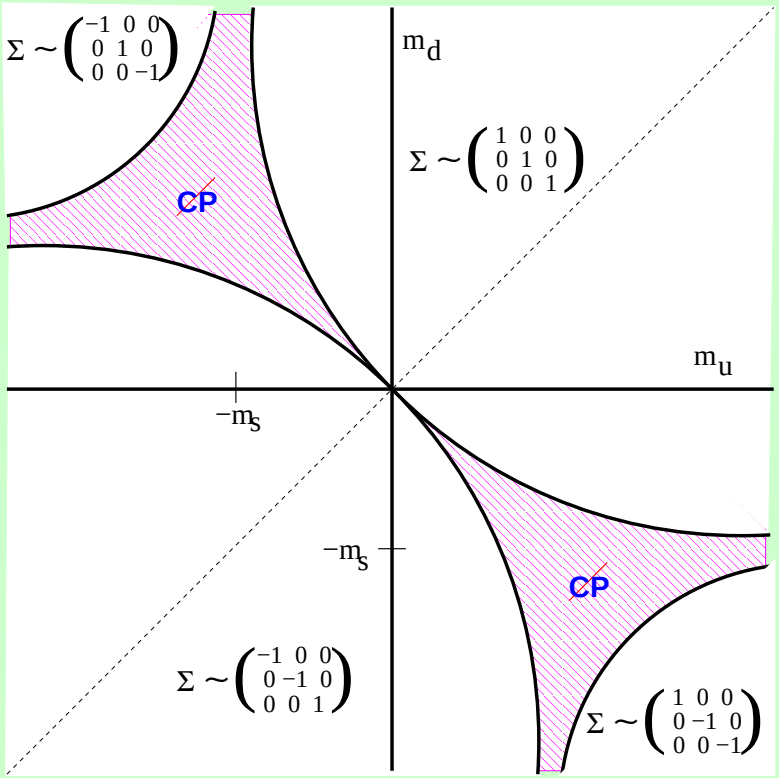
Maximize $\mathrm{Re\ Tr}(M\Sigma)$

$$M = \begin{pmatrix} m_u & 0 & 0 \\ 0 & m_d & 0 \\ 0 & 0 & m_s \end{pmatrix}$$

When solution is complex

- spontaneous CP violation

Sardinia '04



When a single mass vanishes

- no structure
- no Goldstone mode
- anomaly at work

And along comes the staggered cabal

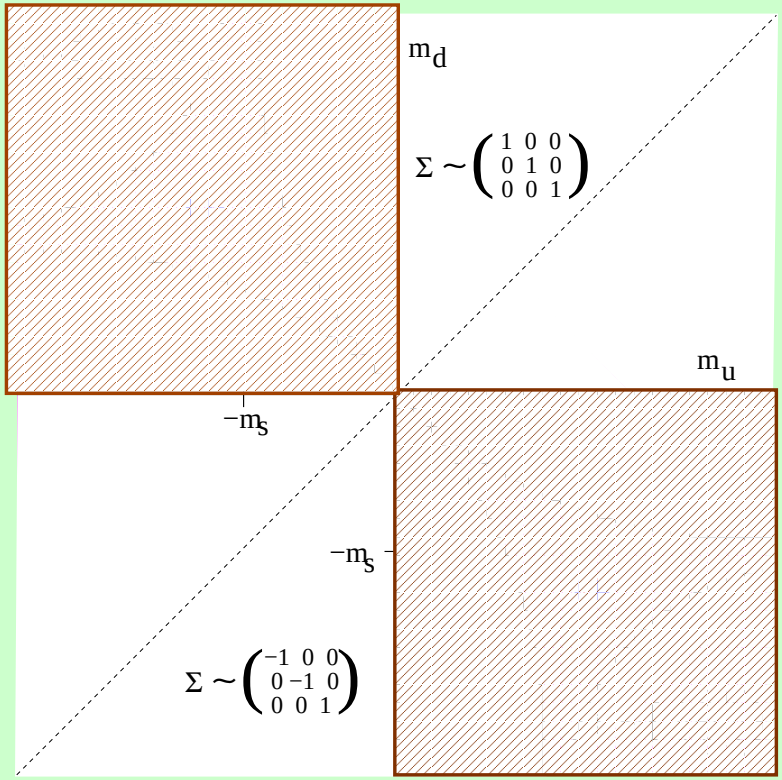
Condoning “rooted staggered quarks”

Unphysical Goldstone modes

- when any mass vanishes
- obscuring interesting regions
- contradicting anomaly

Cancellation in continuum limit?

- non-unitary
- non-local
- unproven

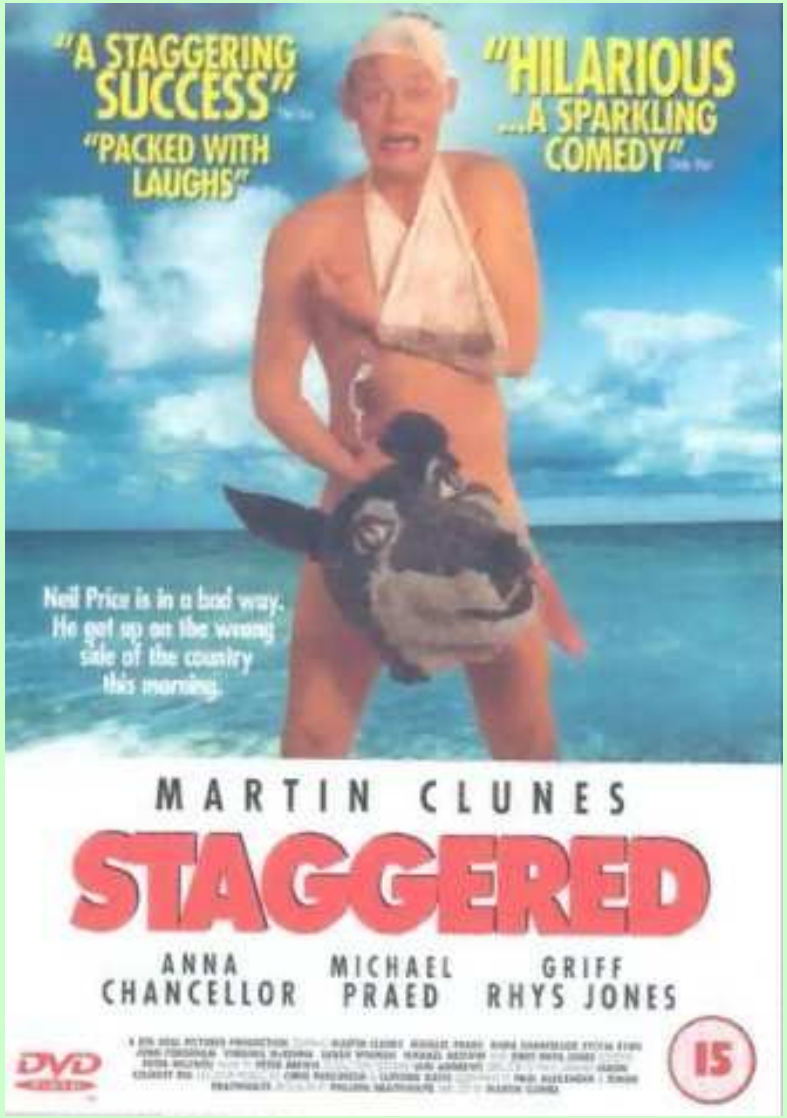


Not an issue with Wilson, domain wall, overlap fermions

Rooting can be unhealthy

© Cathy Weber

But perhaps worth a movie



We find lattices in nice places
Sardinia, 2004

Where we work hard
Boston, 2002

And lay out glass lattices
Gargnano, 2002

And take poster sessions seriously