# Lattice field theory
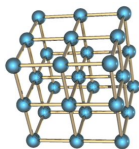
Liam Keegan

November 2015

CERN Theory Group Retreat, Les Houches.
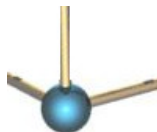
# Large N Twisted Volume Reduction

Lattice field theory:
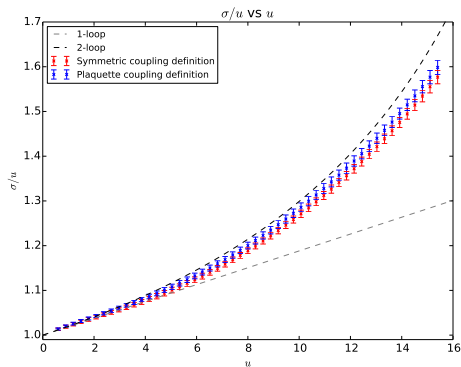


Twisted reduction: $\hat{L} \rightarrow \sqrt{N}$



- ▶ $\hat{L}^4$ points, lattice spacing $a$

- ▶ Physical volume $L^4 = (\hat{L}a)^4$

- ▶ UV cut–off: $1/a$

- ▶ IR cut–off: $1/L$

- ▶ Single site lattice, lattice spacing $a$

- ▶ Physical volume $L^4 = (\sqrt{N}a)^4$
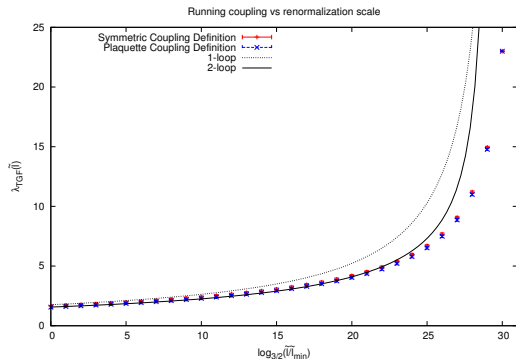
- ▶ UV cut–off: $1/a$

- ▶ IR cut–off: $1/\sqrt{N}a$

# Running Coupling



$\sigma/u$ vs $u$

[Margarita García Peréz, Antonio González-Arroyo, Masanori Okawa]

- SU($N = \infty$) running coupling from $1^4$ lattice

- N from 64 to 324

- Different discretizations consistent with each other

- Agrees with 2–loop perturbation theory

# Running Coupling



Running coupling vs renormalization scale

[Margarita García Peréz, Antonio
González-Arroyo, Masanori Okawa]

- ▶ SU($N = \infty$) running coupling from $1^4$ lattice

- ▶ N from 64 to 324

- ▶ Different discretizations consistent with each other
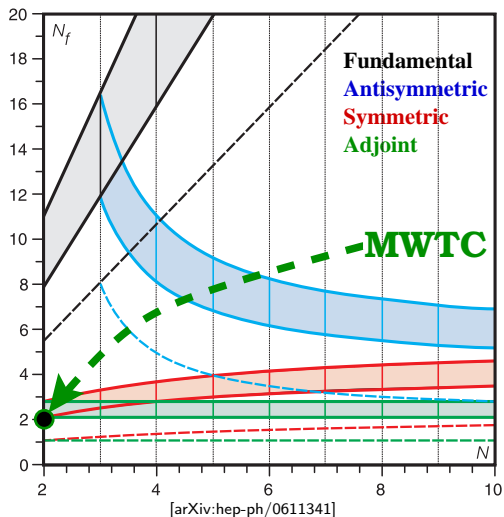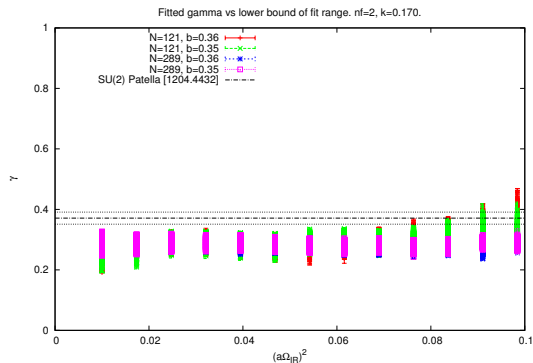
- ▶ Agrees with 2–loop perturbation theory

# Walking/Conformal Gauge Theories



[arXiv:hep-ph/0611341]

- ▶ Perturbative phase diagram of SU(N) gauge theories with $N_f$ fermions

- ▶ Shaded region shows conformal window

- ▶ Can be very different to QCD
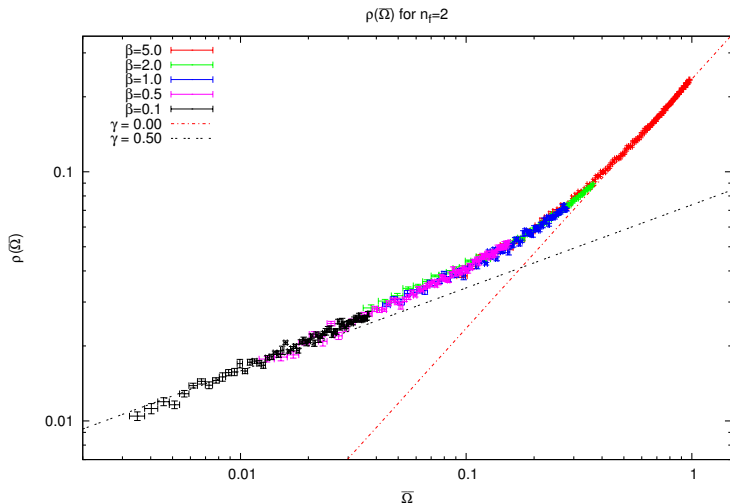
# Mass Anomalous Dimension at IRFP $\gamma_*$



Fitted gamma vs lower bound of fit range. nf=2, k=0.170.

N=121, b=0.36
N=121, b=0.35
N=289, b=0.36
N=289, b=0.35
SU(2) Patella [1204.4432]

[Margarita García Peréz, Antonio
González-Arroyo, Masanori Okawa]

- SU(N) + 2 adjoint Dirac fermions

- $\gamma_*$ determined from fit to the Dirac mode number

- data points: SU(N) with N=289 (single site)

- dotted line: SU(2) ($32^4$ lattice) [Patella 1204.4432]

# Simple model to investigate systematics

- Massive $n_f = 2$ Schwinger Model: 2d QED + 2 Dirac fermions
- Analytic predictions available in UV and IR limits
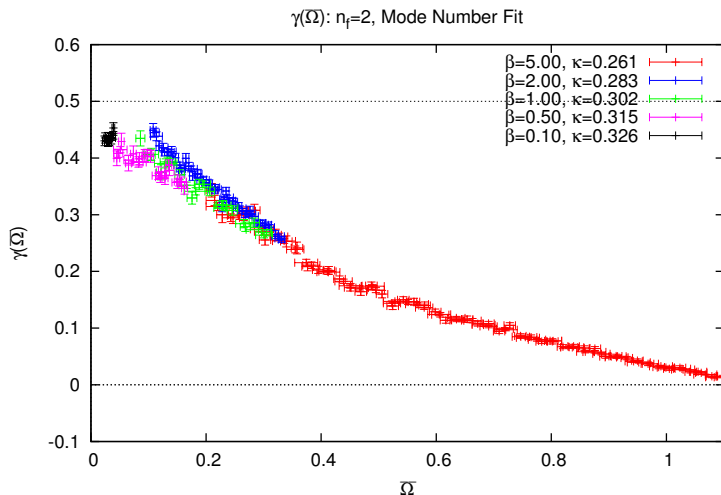


$\rho(\bar{\Omega})$ for $n_f$=2

# Simple model to investigate systematics

- Massive $n_f = 2$ Schwinger Model: 2d QED + 2 Dirac fermions
- Analytic predictions available in UV and IR limits



$\gamma(\overline{\Omega})$: $n_f$=2, Mode Number Fit

Legend:
- $\beta$=5.00, $\kappa$=0.261
- $\beta$=2.00, $\kappa$=0.283
- $\beta$=1.00, $\kappa$=0.302
- $\beta$=0.50, $\kappa$=0.315
- $\beta$=0.10, $\kappa$=0.326

Axes: $\gamma(\overline{\Omega})$ vs $\overline{\Omega}$

# PROMENADE ROMANTIQUE

**SCHUMANN**
SYMPHONIE N° 4 EN RÉ MINEUR

**TCHAÏKOVSKI**
VARIATIONS SUR UN THÈME ROCOCO
LE LAC DES CYGNES SUITE DU BALLET N° 2

## ORCHESTRE DES NATIONS UNIES
ANTOINE MARGUIER
DIRECTION

## CAMILLE THOMAS
VIOLONCELLE

**29 novembre 2015 | 17h**
Victoria Hall, Genève

EN FAVEUR DE:

Orchestre des Nations Unies