The anomalous mass dimension from the techniquark propagator in Minimal Walking Technicolor

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[August,Maas,2013: JHEP 1307 (2013) 001, arXiv:1304.4423 [hep-lat]]

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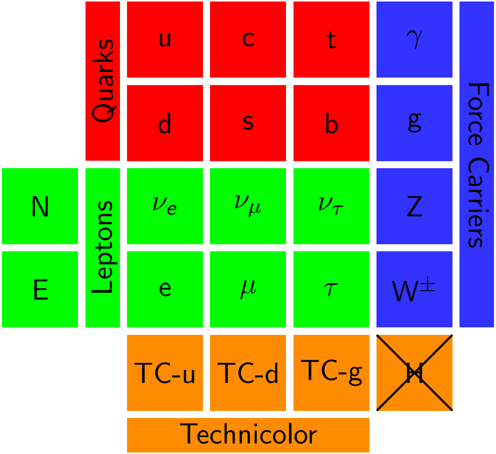
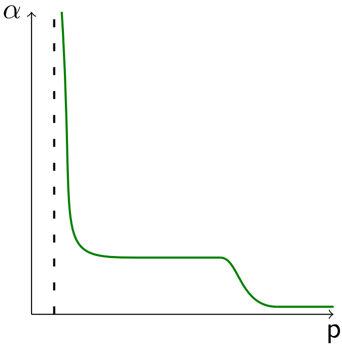
Minimal Walking Technicolor



MWT:

- gauge group SU(2)
- two adjoint flavours
- extra pair of Leptons

Walking



walking dynamics

$$\langle \overline{Q}Q \rangle_{ETC} \sim \left(\frac{\Lambda_{ETC}}{\Lambda_{TC}}\right)^{\gamma} \langle \overline{Q}Q \rangle_{TC}$$

γ is the anomalous mass dimension of the quark propagator

Calculation

Method

- Wilson fermions on the lattice
- inversion with biconjugate gradient method
- lattice corrections
- configurations provided by L. D. Debbio, B. Lucini, A. Patella, C. Pica, A. Rago

Setting

- gauge fixing: minimal Landau gauge $\partial_\mu A_\mu = 0$
- one lattice per value

Quantities

Propagator

$$S(p) = \delta^{ab} \frac{1}{-A(p^2) i\not{p} + B(p^2)} = \delta^{ab} Z\left(p^2\right) \frac{i\not{p} + M(p^2)}{p^2 + M(p^2)^2}$$

$$Z\left(p^2\right) = \frac{1}{A(p^2)} \; , \; M(p^2) = \frac{B\left(p^2\right)}{A(p^2)}$$

Renormalization

$$S\left(p = \mu\right) = \frac{1}{-i\not{p} + m_{PCAC}}$$

Schwinger functions

$$\Delta_v = \frac{1}{\pi} \int_0^\infty dp \cos(tp) \frac{Z(p^2)}{p^2 + M(p^2)^2}$$

$$\Delta_s = \frac{1}{\pi} \int_0^\infty dp \cos(tp) \frac{Z(p^2) M(p^2)}{p^2 + M(p^2)^2},$$

Lattice Corrections

$$pA_L = \frac{tr\gamma_0 S_L}{(tr\gamma_0 S_L)^2 + (trS_L)^2}$$

$$B_L = \frac{trS_L}{(tr\gamma_0 S_L)^2 + (trS_L)^2}$$

free case:

$$pA_L^{free} = \sin\left(\frac{2\pi P_0}{L}\right)$$

$$B_L^{free} = m + 1 - \cos\left(\frac{2\pi P_0}{L}\right)$$

$\rightarrow$ momentum dependent lattice artifacts

$$A = \frac{A_L}{A_L^{free}}$$

$$B = \frac{B_L \cdot m}{B_L^{free}}$$

Mass function

explicit chiral symmetry breaking

$$M\left(p\right)=M\left(\mu\right)\left(\omega\ln\left(\frac{p^2}{\mu^2}\right)+1\right)^{-\gamma}$$

spontaneously broken

$$M\left(p\right)=\frac{2\pi^2\gamma_f}{3}\frac{-\left\langle\overline{\Psi}\Psi\right\rangle}{p^2\left(\frac{1}{2}\ln\frac{p^2}{\Lambda^2}\right)^{1-\gamma_f}}$$

$\rightarrow$ fit function which interpolates both

$$M(p)=\frac{2\pi^2(1-\gamma)}{3}\frac{-\langle\bar{\Psi}\Psi\rangle}{(p+a^2)^{2b}\left(\frac{1}{2}\ln\frac{p^2+c^2}{\Lambda^2}\right)^{\gamma}}$$

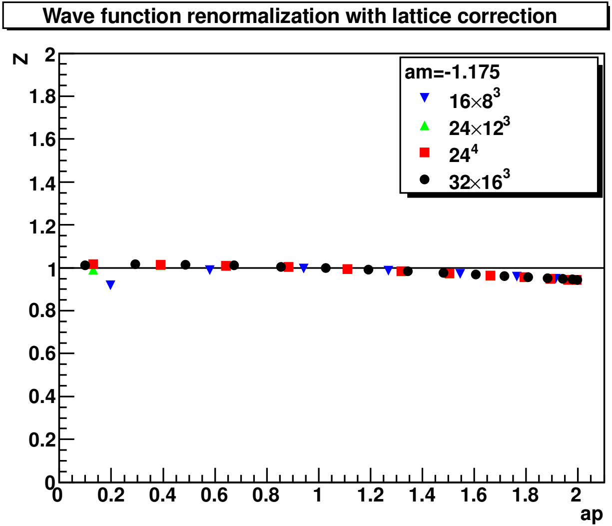
everything except p is a free fit parameter!

Wrong phase

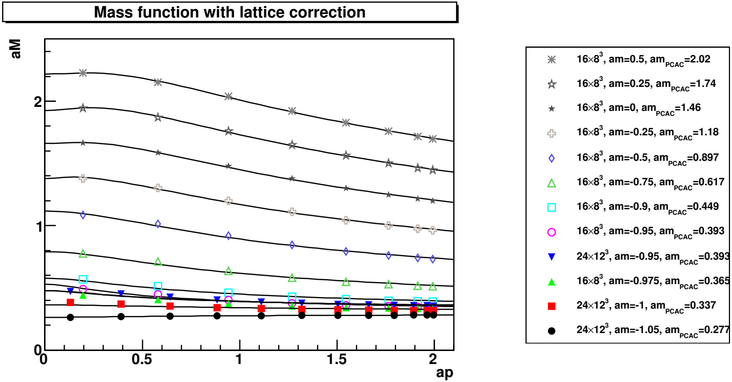
- most interesting physics for small quark masses
- observed spatial center-breaking transition
  L. D. Debbio et al.,2010:arXiv:1004.3206 [hep-lat]
  bounds: below $am = -0.975$ for $N_s = 8$, below $am = -1.05$ for $N_s = 12$ and between $am = -1.05$ and $am = -1.15$ for $N_s = 16$
- this suggests changing bare mass at fixed β changes the lattice spacing$\rightarrow$ volume shrinks toward the chiral limit
- supported by gluonic observables A. Maas,2011: arXiv:1102.5023
- phase transition due the shrinking volume like in YM-theory

$\rightarrow$ we assume this is a pure lattice artifact

Wave function renormalization



Mass function



$$M(p) = \frac{2\pi^2(1-\gamma)}{3} \frac{-\langle\bar{\Psi}\Psi\rangle}{(p+a^2)^{2b}\left(\frac{1}{2}\ln\frac{p^2+c^2}{\Lambda^2}\right)^{\gamma}}$$

Fit parameters

am_0	N_t	2b	γ
0.5	16	0.18(2)	0.033(6)
0.25	16	0.18(2)	0.028(8)
0	16	0.18(2)	0.020(8)
-0.25	16	0.17(2)	0.009(7)
-0.5	16	0.15(2)	0.01(2)
-0.75	16	0.11(2)	0.03(2)
-0.9	16	0.06(3)	0.04(2)
-0.95	16	0.01(7)	0.07(6)
-0.95	24	0.02(3)	0.04(2)
-0.975	16	0.04(11)	0.11(11)
-1	24	0.00(2)	0.03(2)
-1.05	24	0.02(4)	0.00(3)

$$M(p) = \frac{2\pi^2(1-\gamma)}{3} \frac{-\langle\bar{\Psi}\Psi\rangle}{(p+a^2)^{2b}\left(\frac{1}{2}\ln\frac{p^2+c^2}{\Lambda^2}\right)^{\gamma}}$$

Fit parameters

am_0	N_t[TeV]	γ
-0.90	16	0.50(1)
-0.95	16	0.33(1)
-0.95	24	0.23(1)
-1.00	24	0.10(1)

$$M(p) = \frac{1}{a}\left(\omega \ln(p) + k\right)^{-\gamma}$$

L. D. Debbio et al.,2010:arXiv:1004.3206 [hep-lat]

A. Patella,2012: arXiv:1204.4432 [hep-lat]

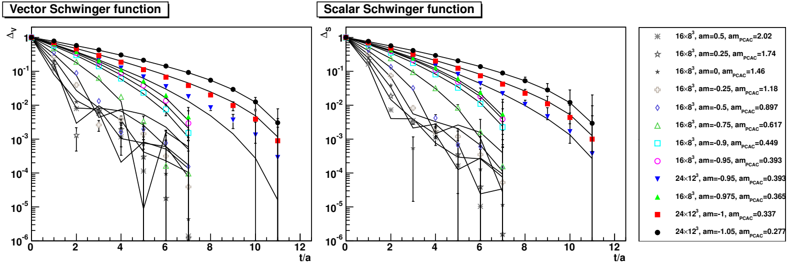
J. Giedt, E. Weinberg,2012: arXiv:1201.6262 [hep-lat]

F. Bursa et al.,2009:, arXiv:0910.4535 [hep-ph]

T. DeGrand et al.,2011: arXiv:1102.2843 [hep-lat]

B. Lucini,2009: arXiv:0911.0020 [hep-ph]

Schwinger functions



bent down $\rightarrow$ unphysical particle

Conclusion

- direct calculation of the anomalous mass dimension of the quark propagator in MWT
- for small masses no spontaneously broken symmetry
- small anomalous mass dimension for explicit chiral symmetry breaking is in line with previous results
- techniquark unphysical particle