Computation of the string tension in three dimensional Yang-Mills theory using large N reduction

Joe Kiskis
UC Davis
Rajamani Narayanan
Florida International University

Outline

- Quick result
- Introduction
- Details
- Conclusion

Quick result

arXiv:0807.1315

- 5^3 lattice
- N = 47
- $b = \frac{1}{g^2 N}$ = 0.6 to 0.8
- Wilson loops 1x1 to 7x7
- $\sqrt{\sigma} b = 0.1964 \pm 0.0009$ (continuum extrapolation)

Introduction

- Large N
- Large N reduction
- Phase structure
- Project description

Large N

- Expansion parameters $\alpha(Q^2)$ or 1/N
- $N \to \infty$ simplifications
  - Planar graphs
  - Factorization
  - Non-interacting mesons
  - OZI rule
- $1/3 \approx 1/\infty$

Large N reduction

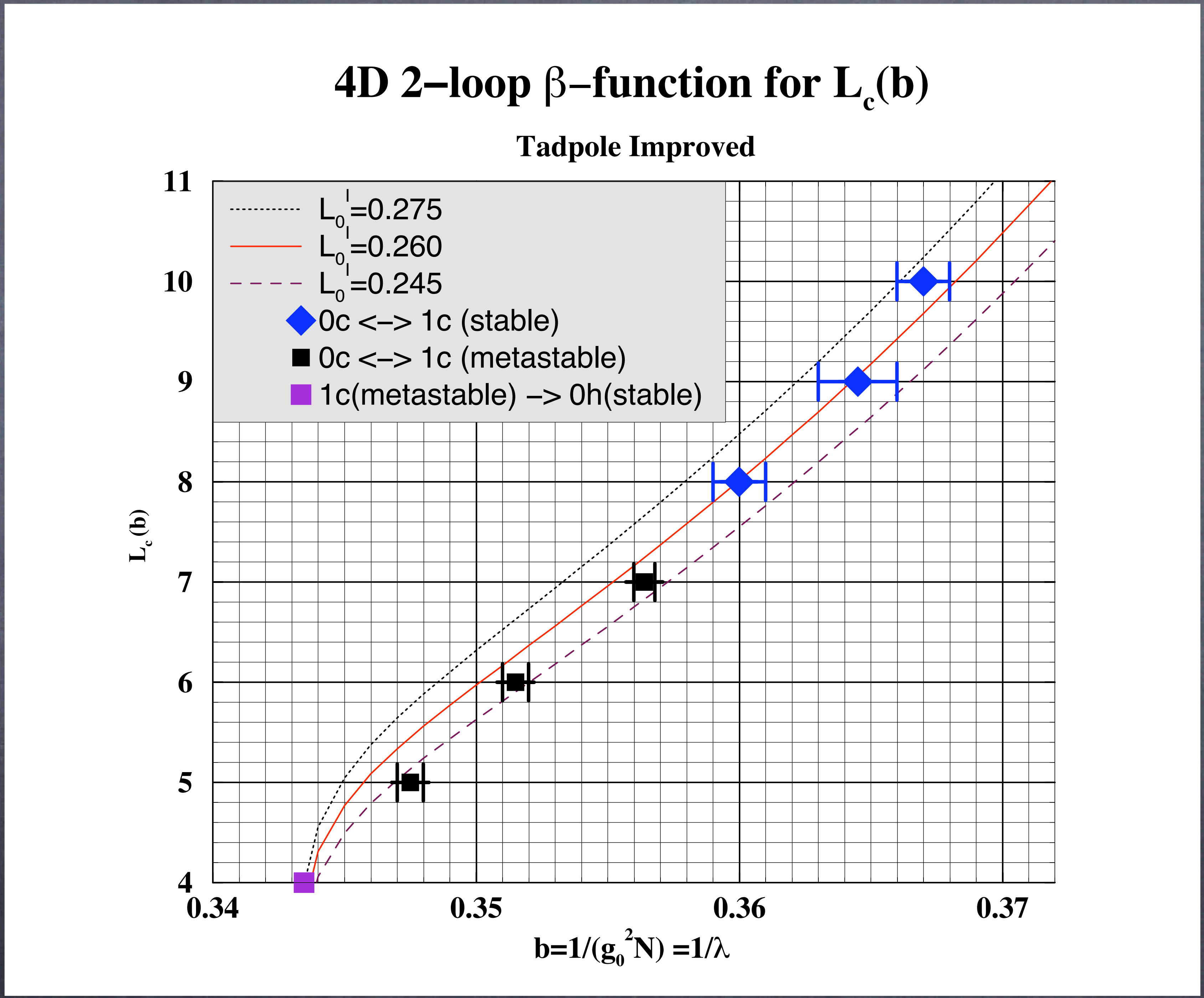
- Reduction to a one point 1^d lattice (Eguchi-Kawai)
- Z_N^d center symmetry
- But broken at weak coupling

Work-arounds

- Quenched E-K
  - But Bringoltz and Sharpe
- Twisted E-K
  - But Teper and Vairinhos
- Continuum or partial reduction
  i.e. reduction to finite physical size
  $l > 1/T_c$

Center symmetry breaking at physical scale

$$Z_N^d \to Z_N^{d-1} \to Z_N^{d-2} \to \;\ldots$$



Kiskis, Narayanan, and Neuberger

Phase structure

3 dimensions

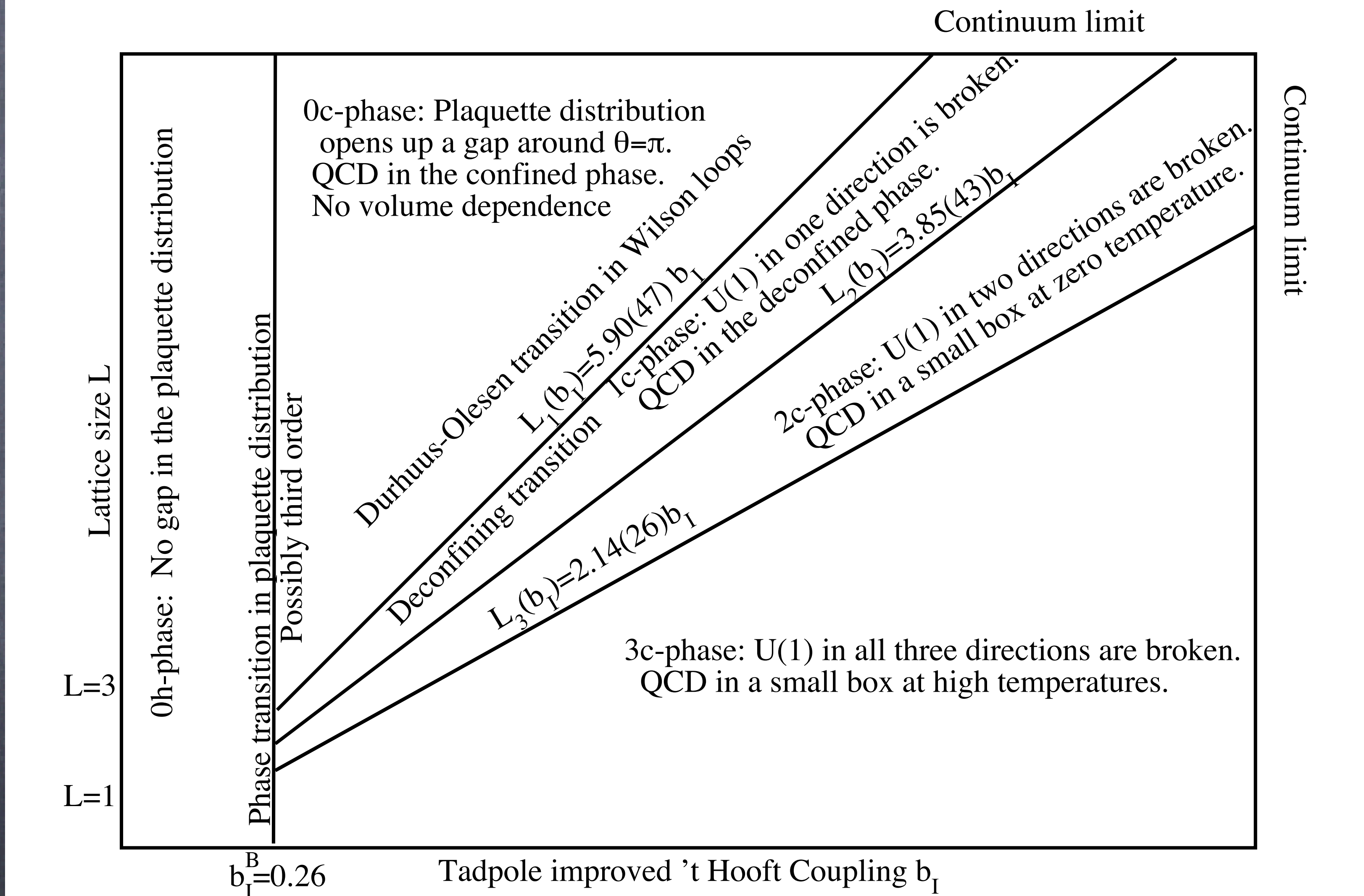


Figure 8: Summary of large N QCD in $d = 3$ on L^3 lattice

Narayanan and Neuberger

Project

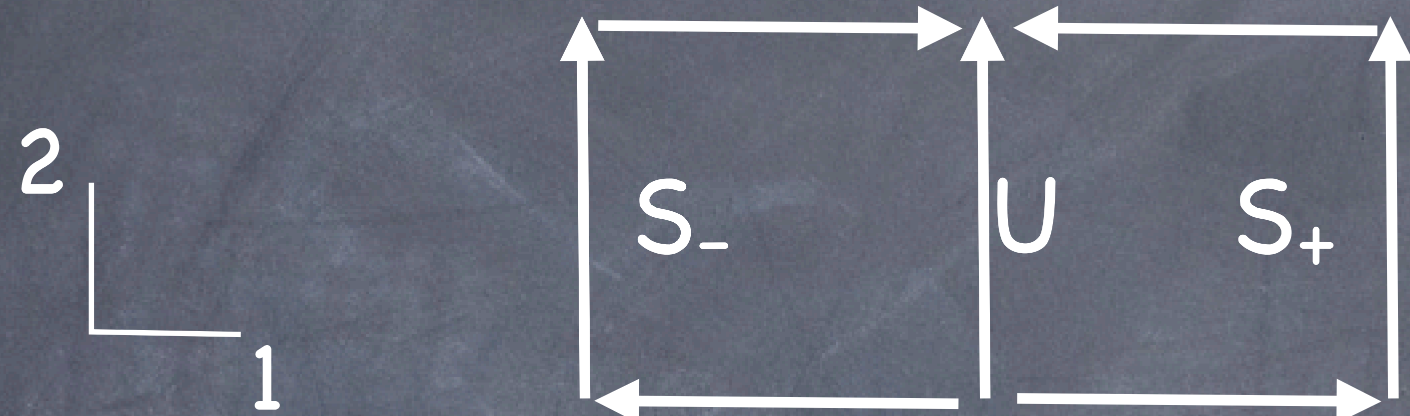
- Context
  - Karabali, Kim, and Nair
    - $\sqrt{\sigma}b = \frac{1}{\sqrt{8\pi}} \approx 0.1995$
  - Bringoltz and Teper
    - Large lattices
    - N up to 8
    - Polyakov loops
    - $\sqrt{\sigma}b = 0.1975 \pm 0.0002 - 0.0005$

- This work
  - 5^3 lattice
  - N = 47
  - b = 0.6 to 0.8
  - Smear space-like links with staples in the same time slice
  - Wilson loops 1x1 to 7x7
  - Fit to get quark-antiquark potential and string tension

Details

- Wilson gauge field action with bare coupling g
- $b = \frac{1}{g^2 N}$ Tadpole improved to $b_I = e(b)b$ with e(b) the average plaquette
- Space-like and time-like separations K, T in lattice units.
- Physical units $k = K/b_I$ and $t = T/b_I$

Smearing



$$U' = P_{SU(N)}[(1-f)U + \frac{f}{2}S_+ + \frac{f}{2}S_-]$$

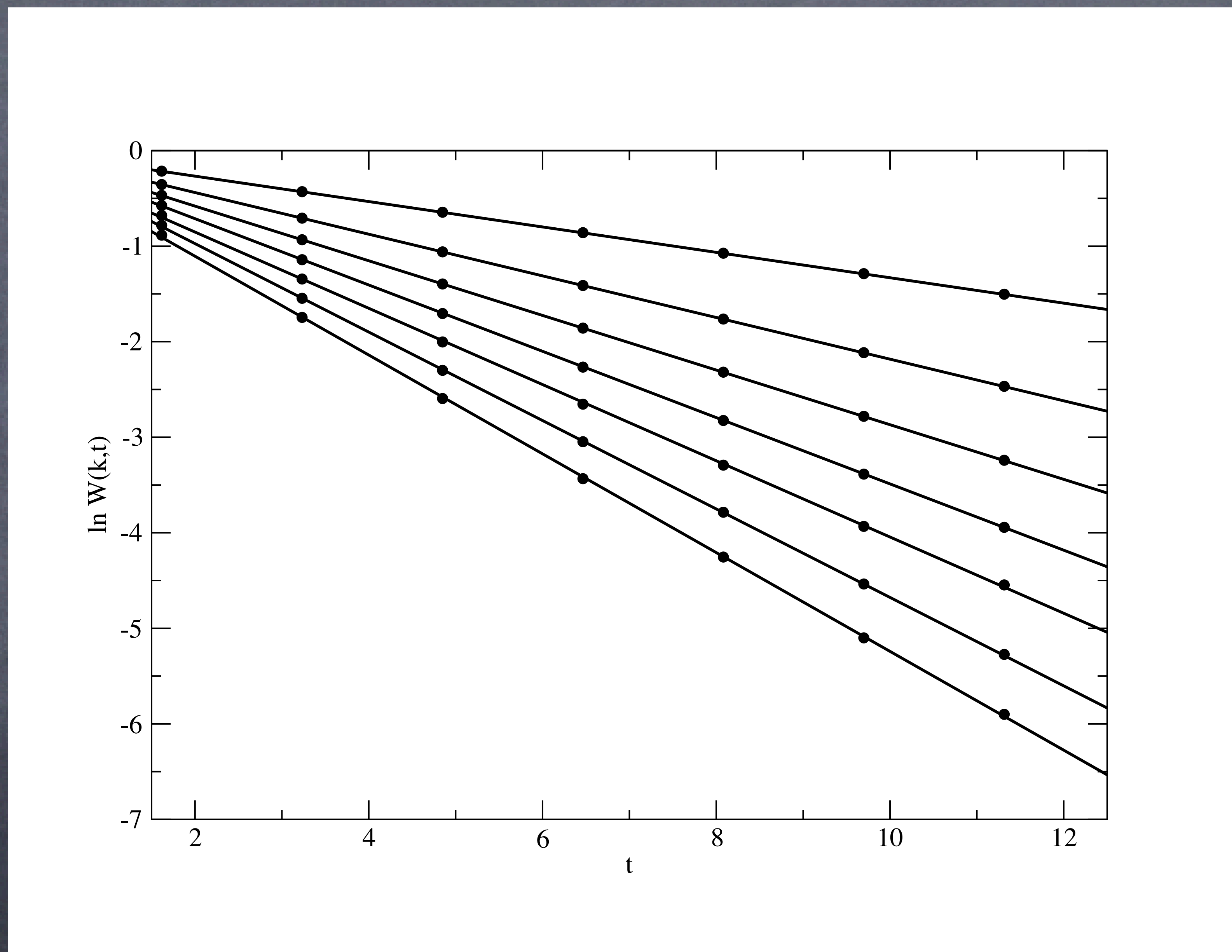
Iterate n times

$$\tau = fn$$

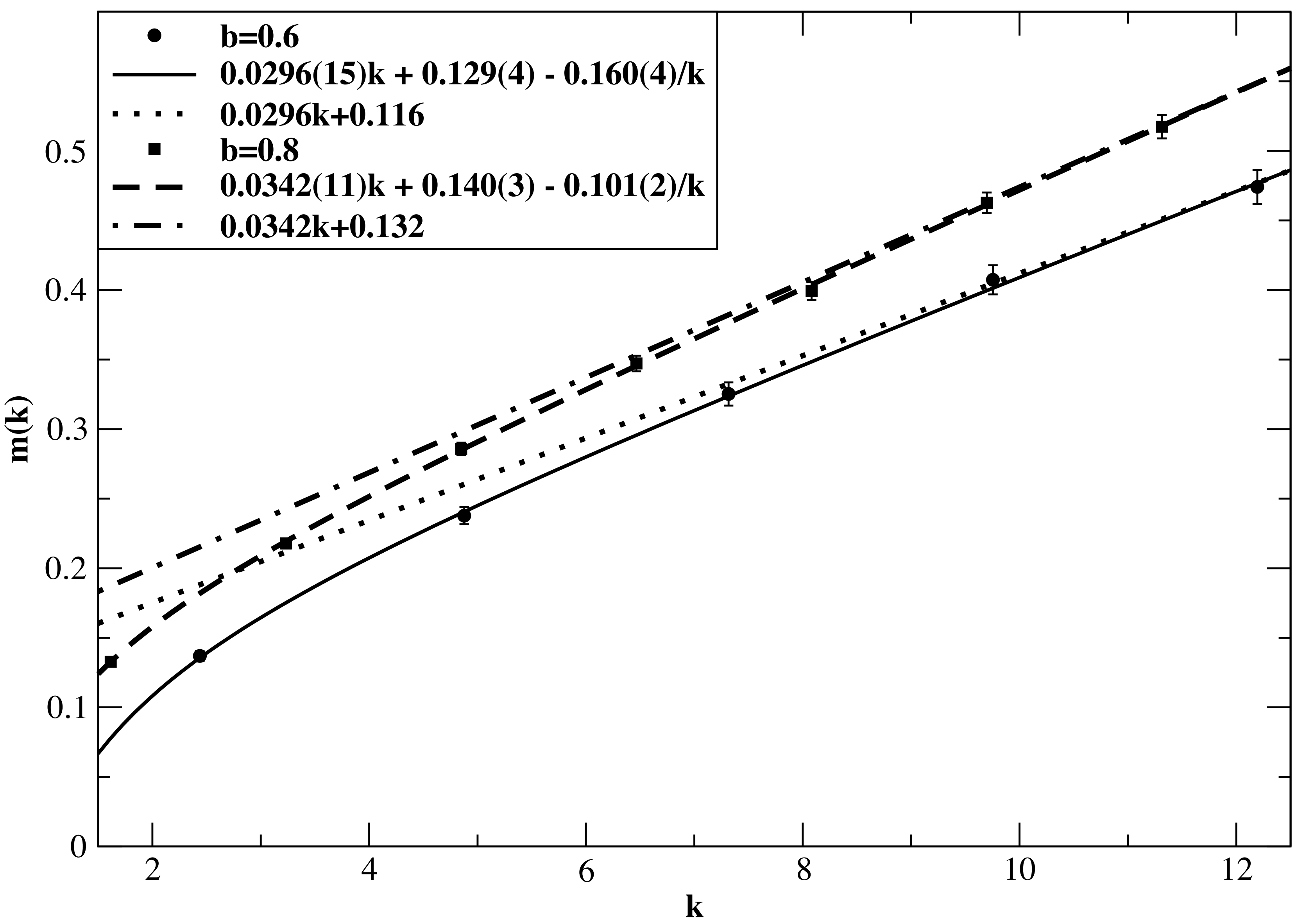
$$f = 0.1 \quad n = 25 \quad \tau = 2.5$$

Compute all Wilson loops 1x1 to 7x7

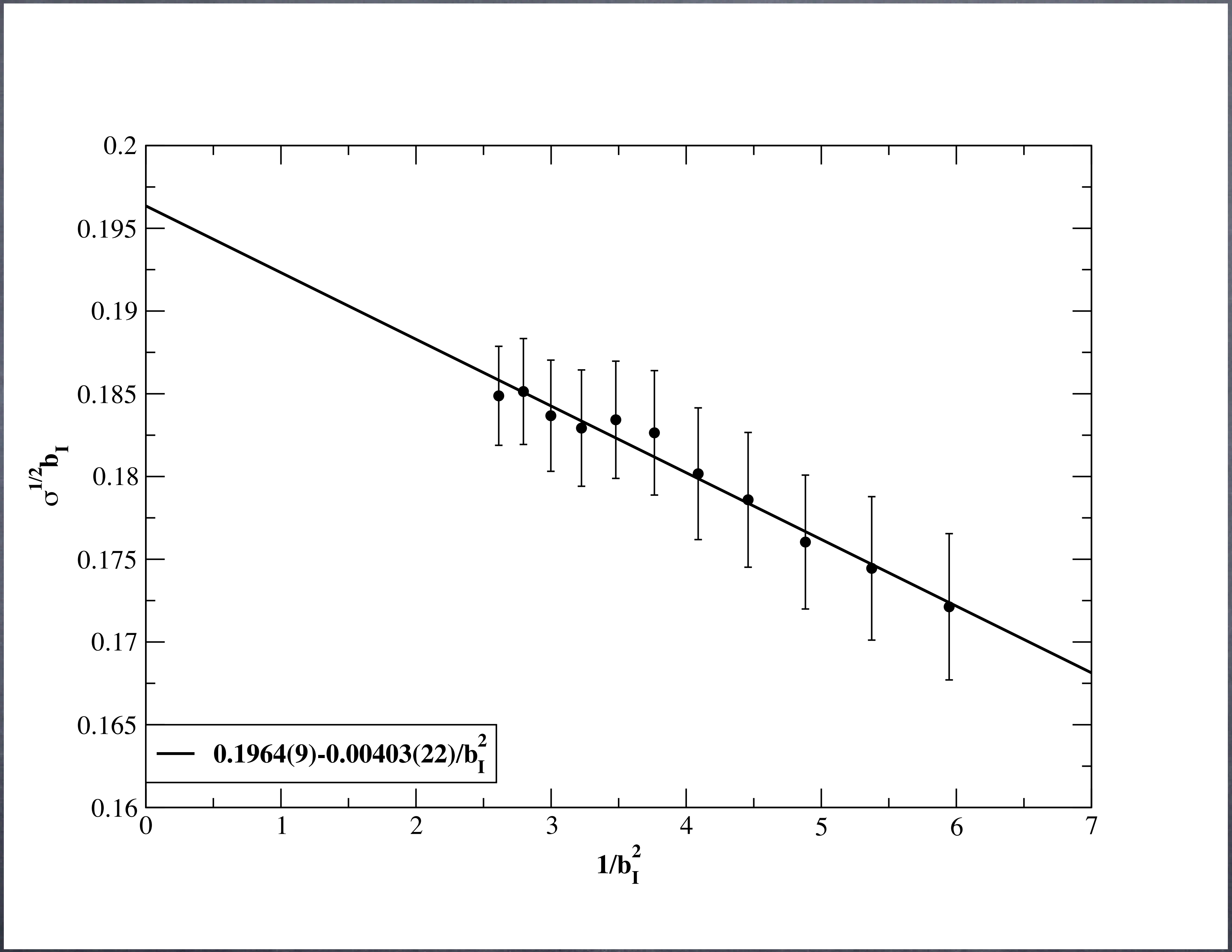
Fit to $W(k,t) = e^{-a-m(k)t}$



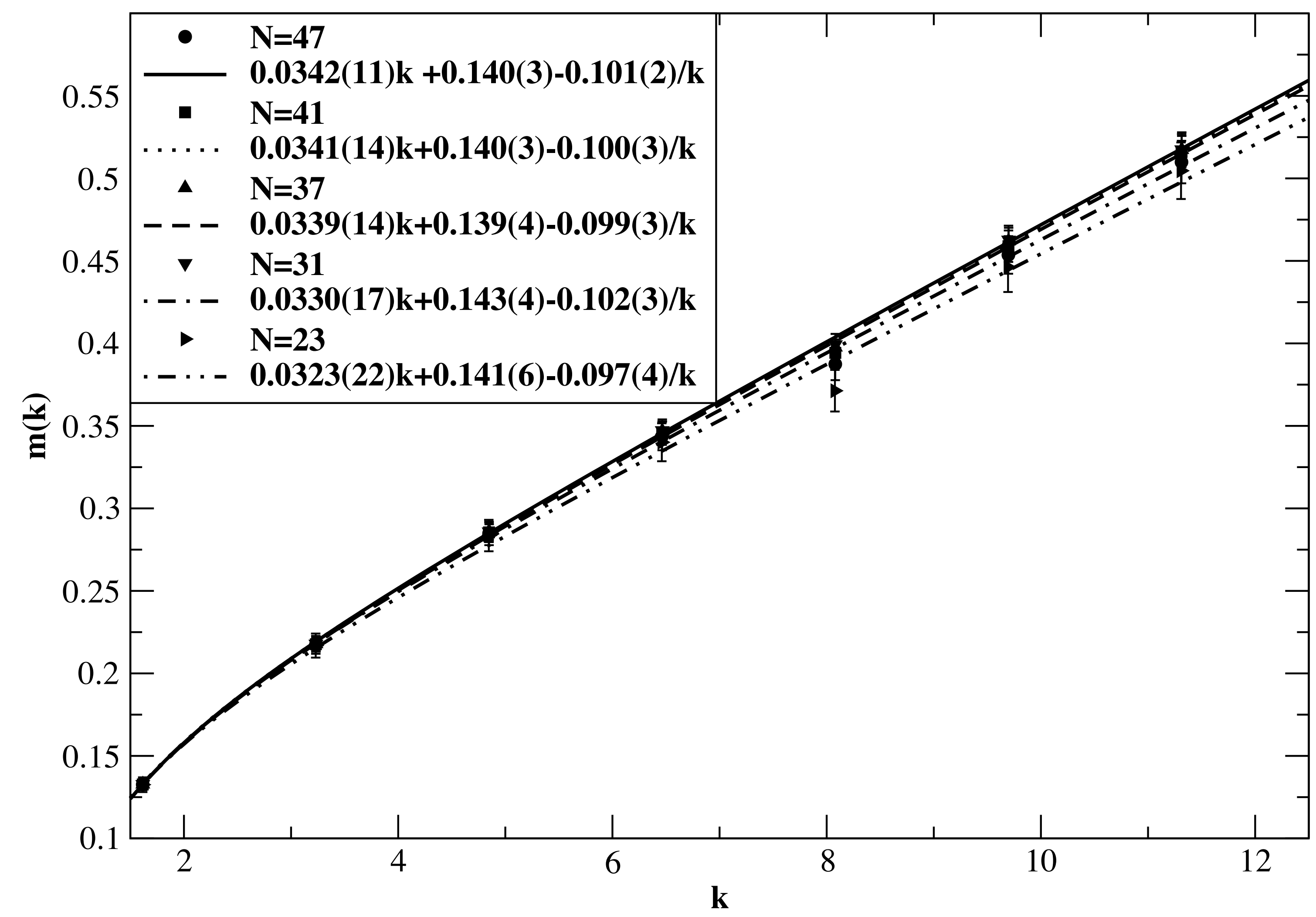
Fit m(k) to $m(k) = \sigma b_I^2 k + c_0 b_I + \frac{c_1}{k}$

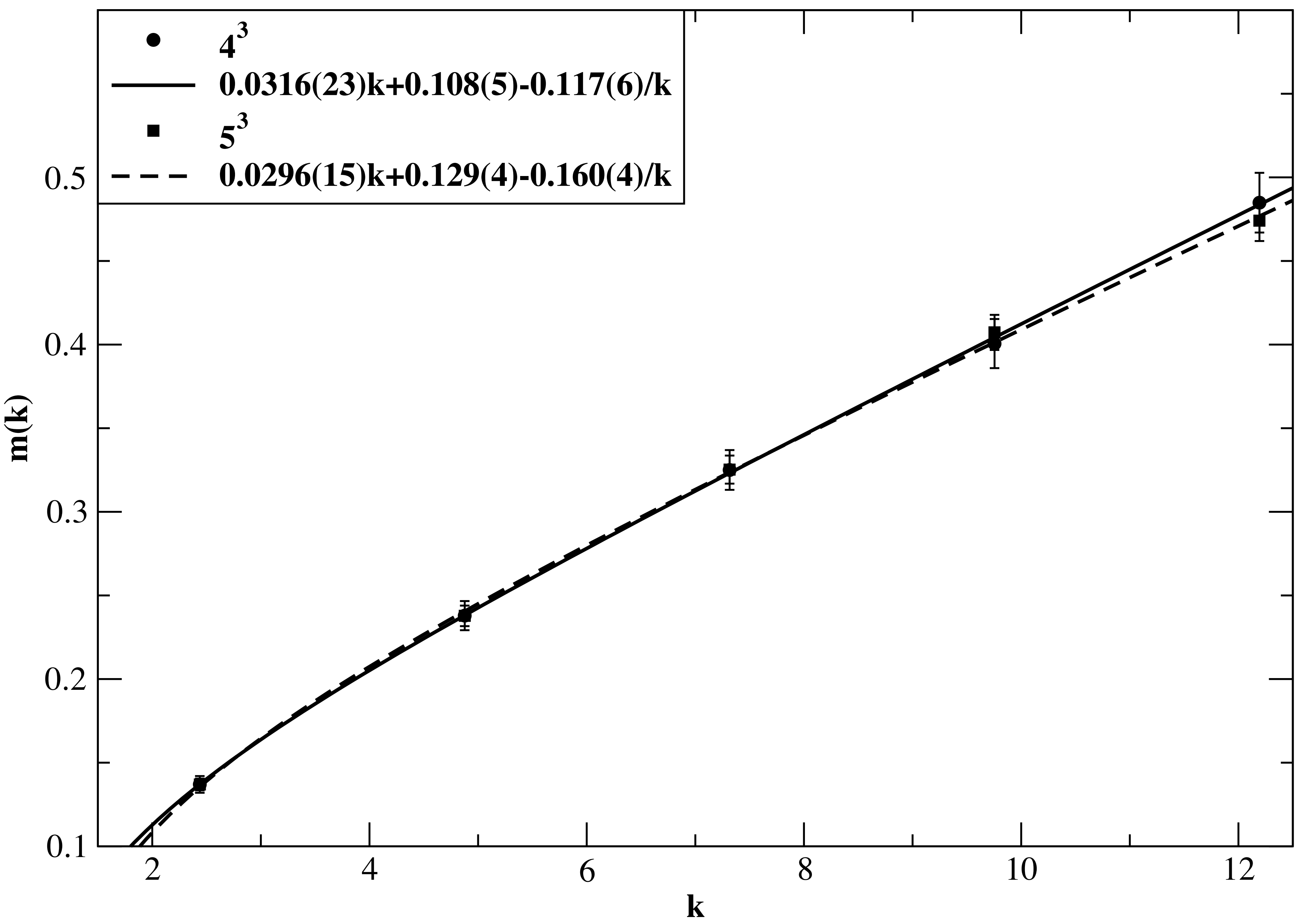


Extrapolate: $b_I \to \infty$ $\quad \sqrt{\sigma} b_I \to 0.1964 \pm 0.0009$



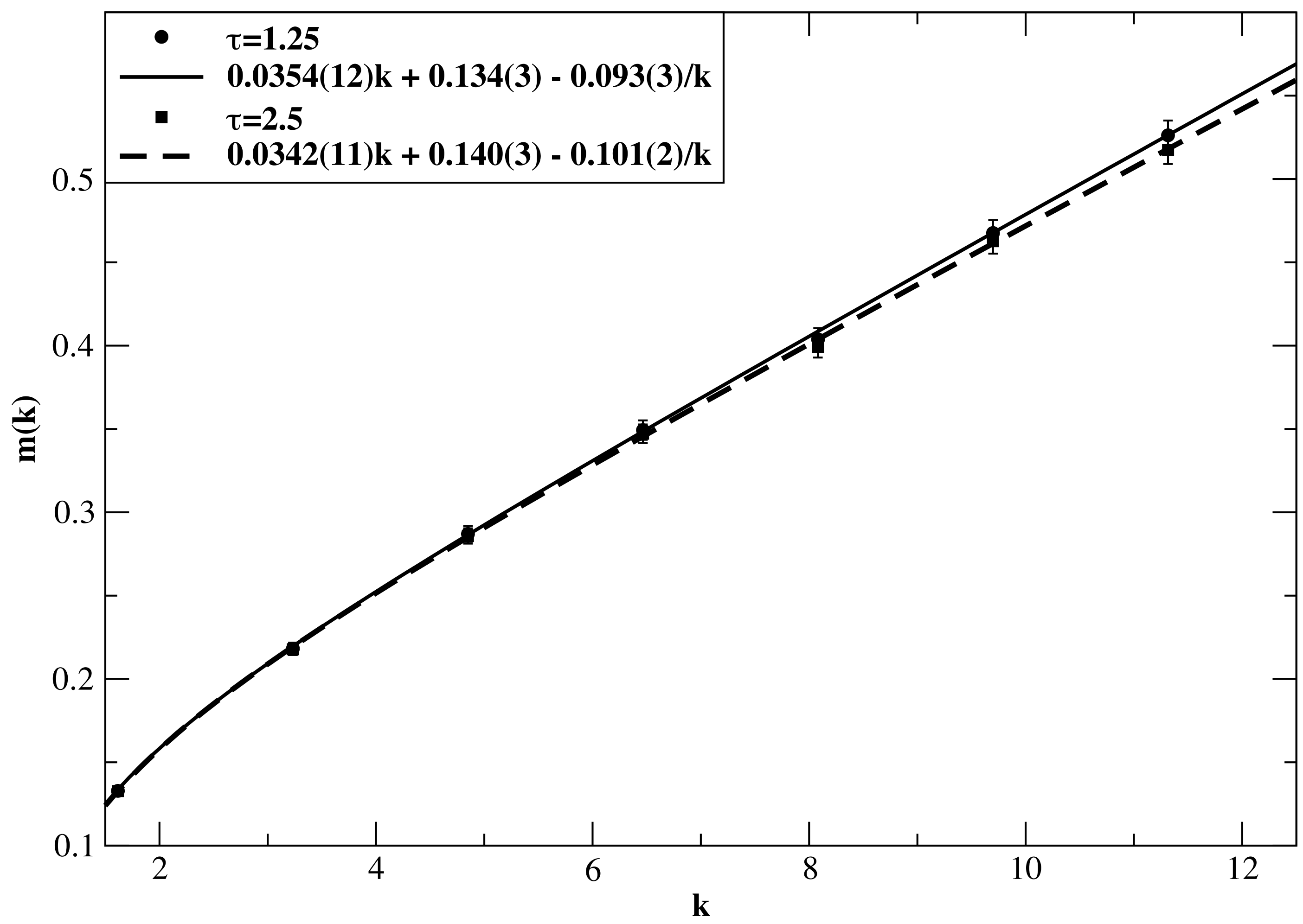
Are N and L large enough?



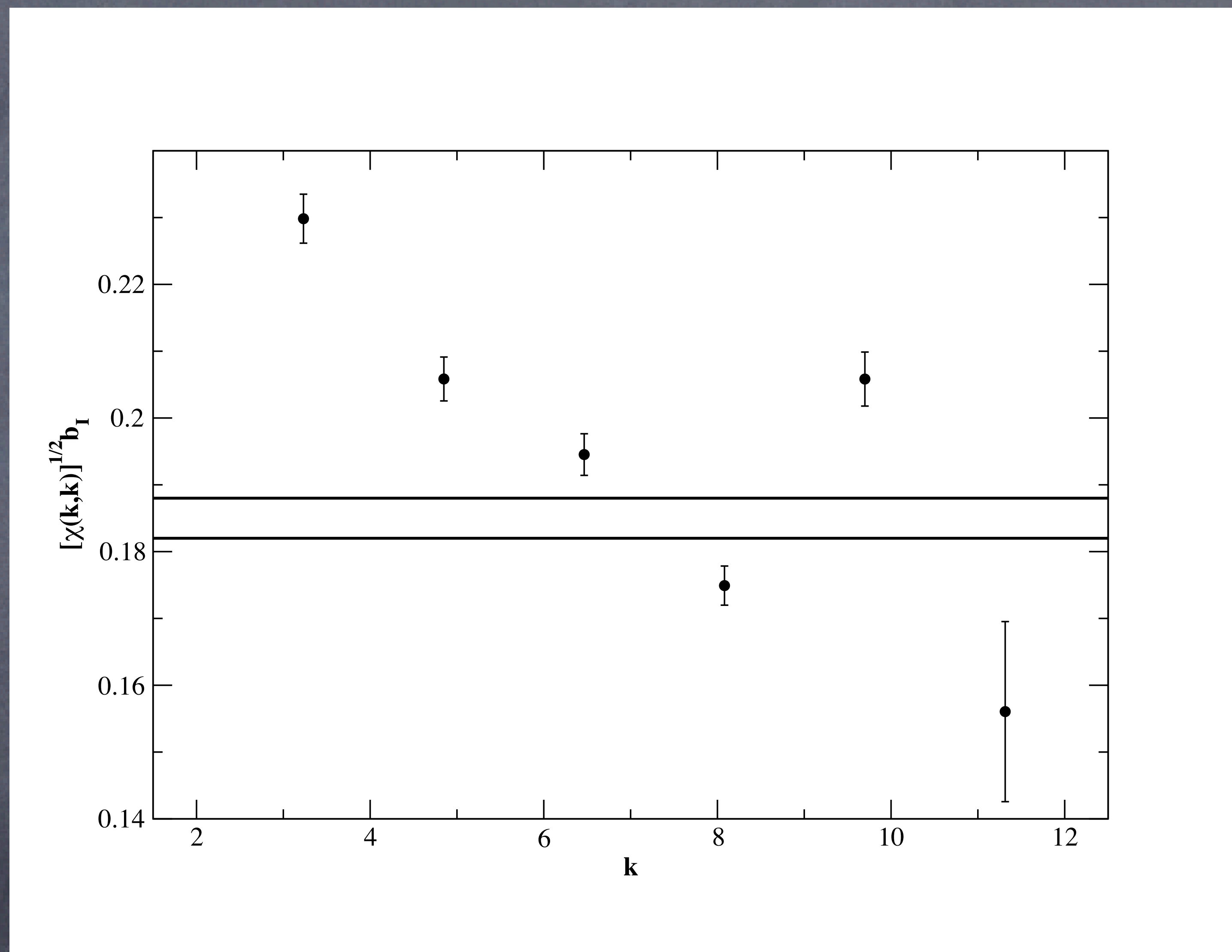


4^3
0.0316(23)k+0.108(5)-0.117(6)/k
5^3
0.0296(15)k+0.129(4)-0.160(4)/k
0.5
0.4
0.3
0.2
0.1
m(k)
2
4
6
8
10
12
k

Are the results sensitive to smearing?



Do Creutz ratios work well?



Conclusion

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