Degeneracy of vector-channel spatial correlators in high T. QCD

C. Rohrhofer, Y. Aoki, G. Cossu, H. Fukaya, L. Glozman, S. Hashimoto, C.B. Lang, S. Prelovsek

21 June 2017, Lattice 2017, Granada

UNI GRAZ

NAWI Graz

FWF Der Wissenschaftsfonds.

Related work

JLQCD collab. (G.Cossu *et al.*) hep-lat/1510.07395
JLQCD collab. (A.Tomiya *et al.*) hep-lat/1612.01908

✓ K. Suzuki (Monday, Nonzero-T)
Axial U(1) symmetry at high temperature in 2-flavor lattice QCD

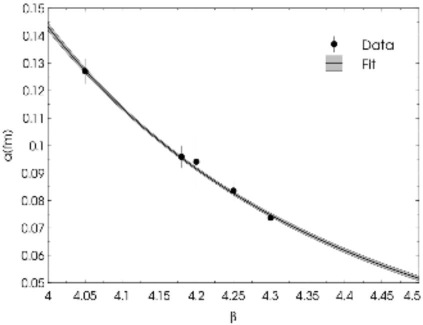
✓ Y. Aoki (Monday, Nonzero-T)
Topological Susceptibility in $N_f = 2$ QCD at Finite Temperature

⇒ H. Fukaya (**Thursday, plenary**)
Is axial U(1) anomalous at high temperature?

What happens to spatial correlators of spin one operators?

Lattice setup

- $n_f = 2$ Möbius DW fermions, Symanzik gauge action
- $32^3 \times 8$ lattices, $T_c = 175\text{MeV}$
- local isovectors $\mathcal{O}_\Gamma(x) = \bar{q}(x)\Gamma q(x)$
- measuring spatial correlations in $z-$direction



β	m_{ud}	T [MeV]	
4.10	0.001	220	$1.3T_c$
4.18	0.001	260	$1.5T_c$
4.30	0.001	330	$1.9T_c$
4.37	0.005	380	$2.2T_c$

G.Cossu *et al.* hep-lat/1510.07395, A.Tomiya *et al.* hep-lat/1612.01908

The Dirac algebra

standard terminology		
$\mathbb{1}$	scalar	1
γ_μ	vector	4
$\sigma_{\mu\nu} = \frac{1}{2}[\gamma_\mu, \gamma_\nu]$	tensor	6
$\gamma_\mu \gamma_5$	pseudo-vector	4
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The tensor elements can be combined to 2 more Vectors:

Tensor **T** and Axial Tensor **X**.

Organizing the Vector components

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Fix direction of propagation (*z-direction*):

$$C_\Gamma(n_z) = \sum_{n_x, n_y, n_t} \langle \mathcal{O}_\Gamma(n_x, n_y, n_z, n_t) \mathcal{O}_\Gamma(0,0,0,0)^\dagger \rangle$$

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Using $\partial_\mu j^\mu = \partial_\mu j_5^\mu = 0$ we identify the Gamma structures for the Vectors:

$$\mathbf{V} = \begin{pmatrix} \gamma_1 & = Vx \\ \gamma_2 & = Vy \\ \gamma_4 & = Vt \end{pmatrix} \quad \mathbf{A} = \begin{pmatrix} \gamma_1\gamma_5 & = Ax \\ \gamma_2\gamma_5 & = Ay \\ \gamma_4\gamma_5 & = At \end{pmatrix}$$

$$\mathbf{T} = \begin{pmatrix} \gamma_1\gamma_3 & = Tx \\ \gamma_2\gamma_3 & = Ty \\ \gamma_4\gamma_3 & = Tt \end{pmatrix} \quad \mathbf{X} = \begin{pmatrix} \gamma_1\gamma_3\gamma_5 & = \gamma_2\gamma_4 & = Xx \\ \gamma_2\gamma_3\gamma_5 & = \gamma_4\gamma_1 & = Xy \\ \gamma_4\gamma_3\gamma_5 & = \gamma_1\gamma_2 & = Xt \end{pmatrix}$$

γ_3 & $\gamma_3\gamma_5$ no propagation due to current conservation!

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What to expect from $\mathcal{L}_{QCD}$ and χS?

	Pseudoscalar		*Scalar*
PS	$(1, 0^{-+})$ $\bar{q}(\vec{\tau} \otimes \gamma_5)q$	**S**	$(1, 0^{++})$ $\bar{q}(\vec{\tau} \otimes \mathbb{1}_D)q$

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V	$(1, 1^{--})$ $\bar{q}(\vec{\tau} \otimes \gamma_k)q$	**A**	$(1, 1^{++})$ $\bar{q}(\vec{\tau} \otimes \gamma_5\gamma_k)q$
	Tensor Vector		*Axial Tensor V.*
T	$(1, 1^{--})$ $\bar{q}(\vec{\tau} \otimes \gamma_3\gamma_k)q$	**X**	$(1, 1^{+-})$ $\bar{q}(\vec{\tau} \otimes \gamma_5\gamma_3\gamma_k)q$

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V	*Vector* $(1, 1^{--})$ $\bar{q}(\vec{\tau} \otimes \gamma_k)q$	$SU(2)_A$ $\longleftrightarrow$	**A**	*Axial Vector* $(1, 1^{++})$ $\bar{q}(\vec{\tau} \otimes \gamma_5\gamma_k)q$
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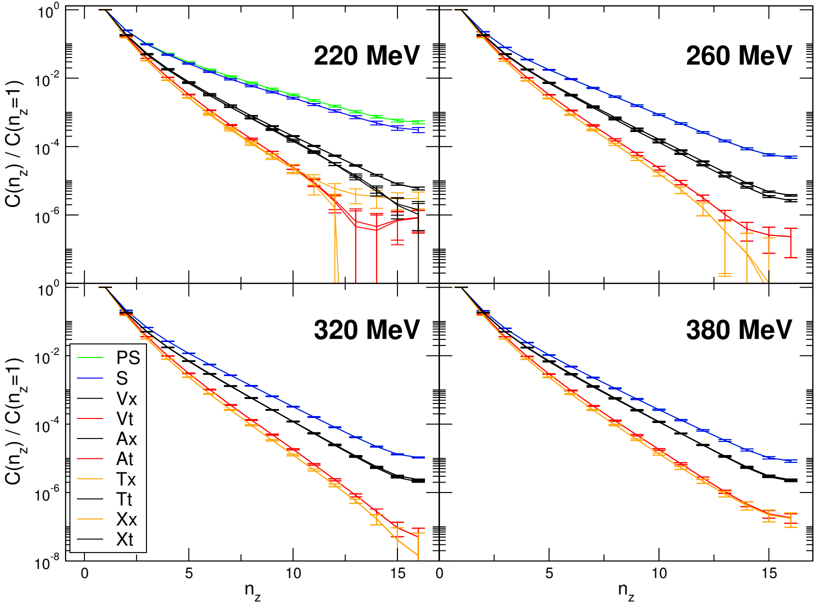

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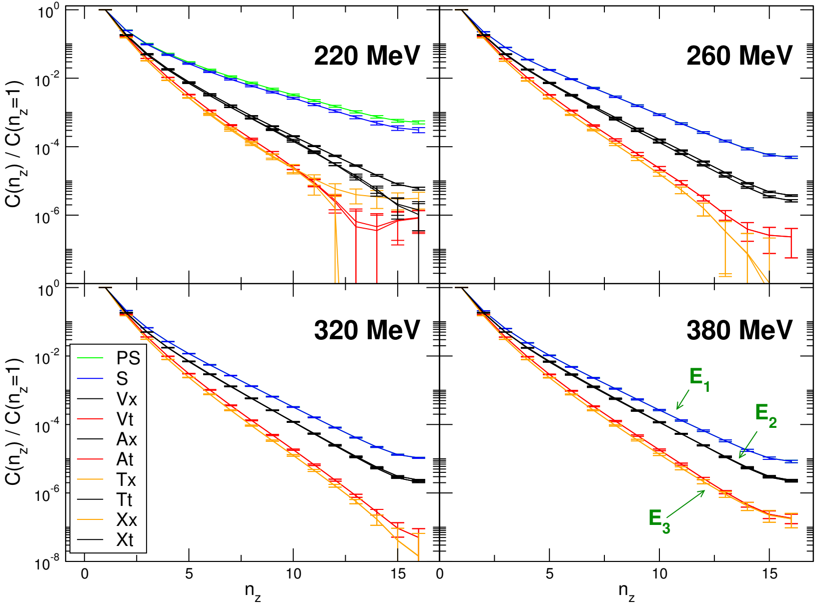

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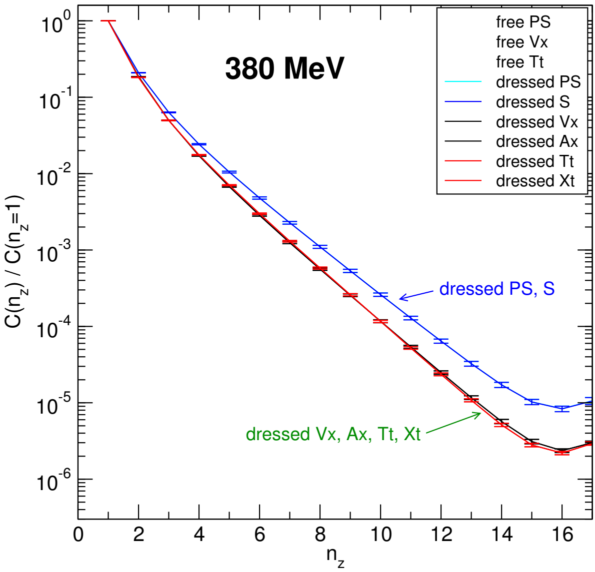

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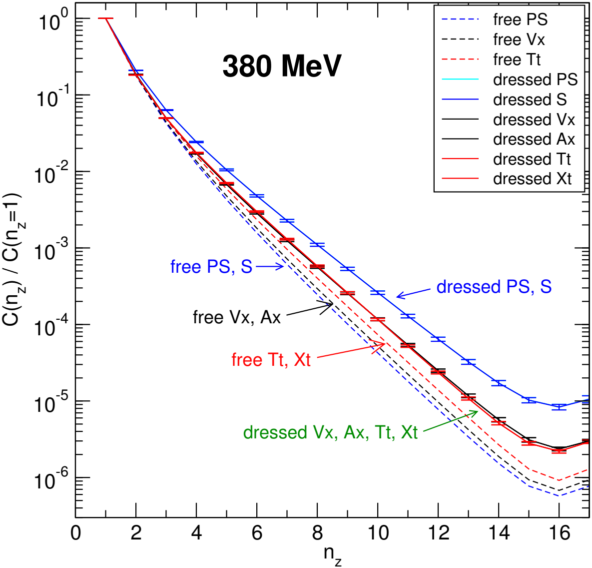
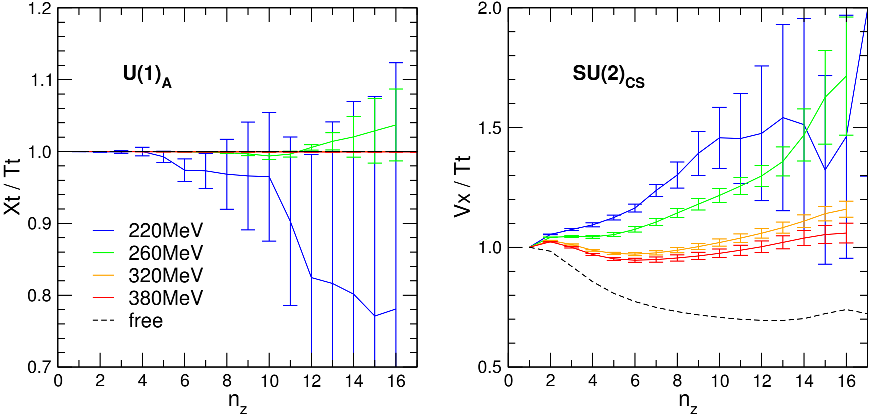


'*free*' $U(x)_\mu = \mathbb{1}$
correlators differ algebraically!

Asymptotic freedom:
sum of free quarks
$C(n_z) \sim e^{-2\omega_0 n_z}$

W.Florkowski & B.L.Friman Z.Phys. A347 (1994) 271-276

$U(1)_A$ and $SU(2)_{CS}$ detailed ratios



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L.Ya.Glozman & M.Pak, hep-lat/1504.02323

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$$\left.\begin{matrix} V_x \leftrightarrow T_t \leftrightarrow X_t \leftrightarrow A_x \\ V_y \leftrightarrow T_t \leftrightarrow X_t \leftrightarrow A_y \end{matrix}\right\} E_2$$
$$\left.\begin{matrix} V_t \leftrightarrow T_x \leftrightarrow X_x \leftrightarrow A_t \\ V_t \leftrightarrow T_y \leftrightarrow X_y \leftrightarrow A_t \end{matrix}\right\} E_3$$

This is exactly what we observe!

L.Ya.Glozman & M.Pak, hep-lat/1504.02323

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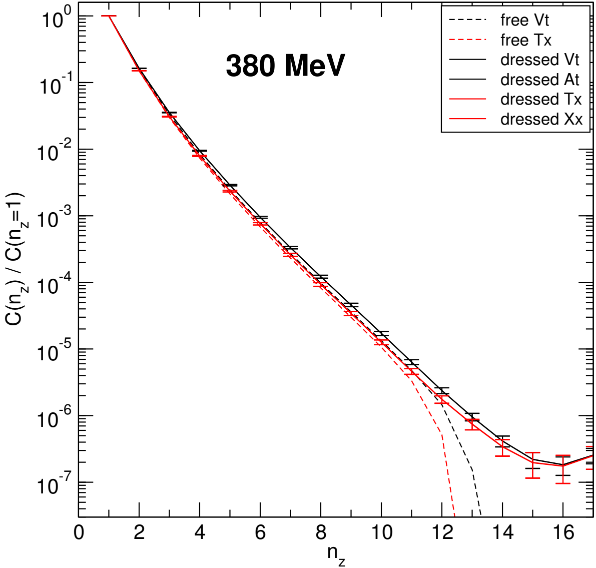

Finite size effects are obvious for non-interacting $U(x)_\mu = \mathbb{1}$ correlators!

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thank you!
ありがとうございます

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