Physics that I shared with Atsushi

Sourendu Gupta

TIFR, Mumbai

Harmonies and Surprises on the Lattice
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Gauge fixing ambiguity and photon propagators in compact U(1) lattice gauge theory

A. Nakamura
Interdisciplinary Project Center for Supercomputing, ETH-Zentrum, CH-8092 Zurich, Switzerland

and

M. Plewnia
Institut für Theoretische Physik, Freie Universität Berlin, W-1000 Berlin 33, FRG

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We present the first numerical evidence of Gribov copies on a lattice. Photon propagators are numerically studied under the non-linear gauge condition $\partial_\mu \sin\theta_\mu = 0$, where θ_μ's are gauge potentials defined on a lattice. It is shown that this standard lattice Landau gauge condition is not unique. In the Coulomb phase a correct free propagator is obtained only after removing this ambiguity.

Atsushi came looking for me and told me about Gribov copies. We met roughly once a month and discussed this problem for some time.

Axial gauge

Problem

Minimize $H(g_i) = \mathrm{Re}\ \sum_{i,\mu} g_i U_\mu(i) g_{i+\mu}$.

Algorithm

Sweep over sites, choosing g_i at each site to minimize H. Iterate to completion. Play with minimization algorithms: version of conjugate gradient also possible.

Gribov copies

- Does result depend on the ordering of the sweep?
- Make initial "large" gauge transformation: $U_\mu(i) \rightarrow U'_\mu(i)$. Does the result change?

Gauge spin-glass

The spin glass connection

$H(g_i) = \sum_{i,\mu} g_i U_\mu(i) g_{i+\mu}$ is the Hamiltonian of a spin glass system (spins in the gauge group) with quenched disorder $U_\mu(i)$. For Z_2 gauge theory the usual spin glass—

$$H = \sum_{i,\mu} J_\mu(i) s_i s_{i+\mu}.$$

How many minima?

Ground state entropy of spin glass is non-zero. Therefore number of minima grows as $\exp(sV)$. Related problem: how many spanning trees on a cubic lattice? Also $\mathcal{O}[\exp(V)]$. Questions: in any gauge, the number of Gribov copies $\mathcal{O}[\exp(V)]$? Is thermodynamics self-averaging?

One specific problem

Local obstructions

Make random local large gauge transformations. Some transformations are irrelevant: the final gauge fixed configuration is the same. But some local transformations lead to quite different gauge fixed link configuration. Is there a gauge-invariant local property which says where the Gribov copy diverge from? Went from U(1) to Z_2 to investigate this, but did not reach a conclusion.

Genetic algorithm

However, followed up this idea to write a genetic algorithms for Landau gauge fixing and locating minimum of minima. Local information incorporated into the genetic algorithm through partitioning of the lattice. Claimed to be "fast" but no information on speeds recorded.

Hadron masses at finite density

Screening mass responses to chemical potential at finite temperature*

QCD-TARO Collaboration: S. Choe[a], Ph. de Forcrand[b], M. García Pérez[c], S. Hioki[d], Y. Liu[a], H. Matsufuru[e], O. Miyamura[a], A. Nakamura[f], I.-O. Stamatescu[g,h], T. Takaishi[i], and T. Umeda[j]

[a] Department of Physics, Hiroshima University, Higashi-Hiroshima 739-8526, Japan
[b] Institut für Theoretische Physik, ETH-Hönggerberg,CH-8093 Zürich,Switzerland
[c] Theory Division, CERN, CH-1211 Geneva 23, Switzerland
[d] Department of Physics, Tezukayama University, Nara 631-8501, Japan
[e] Yukawa Institute for Theoretical Physics, Kyoto University, Kyoto 606-8502, Japan
[f] IMC, Hiroshima University,Higashi-Hiroshima 739-8521, Japan
[g] Institut für Theoretische Physik, Universität Heidelberg, D-69120 Heidelberg, Germany
[h] FEST, Schmeilweg 5, D-69118 Heidelberg, Germany
[i] Hiroshima University of Economics, Hiroshima 731-0192, Japan
[j] Center for Computational Physics, University of Tsukuba, Tsukuba 305-8577, Japan

Responses to chemical potential of the pseudoscalar meson screening mass and the chiral condensate in lattice QCD are investigated. On a $16 \times 8^2 \times 4$ lattice with two flavors of staggered quarks the first and second responses below and above T_c are evaluated. Different behavior in the low and the high temperature phases are observed, which may be explained as a consequence of the chiral symmetry breaking and restoration.

Parametrize the correlation function

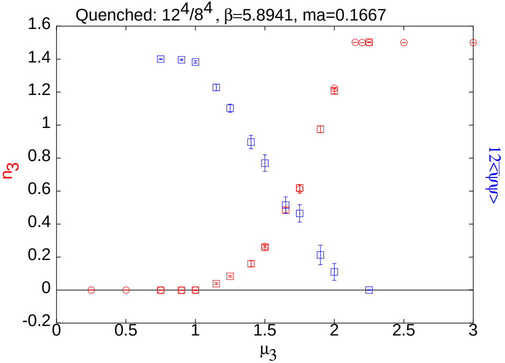
$$C(r) = A\cosh[m(r - L/2)],$$

then take derivative of each side with chemical potential. **Very interesting question**

See also Kogut, Lombardo and Sinclair, Phys. Rev. D 51 (1995) 1282.

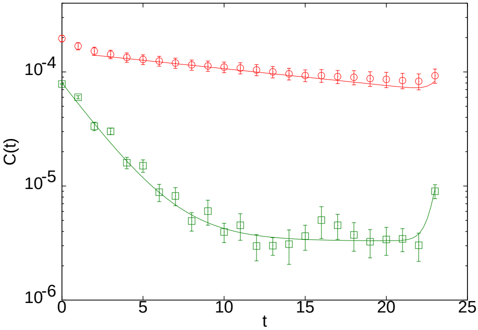
Quenched QCD at finite μ_3

Wilson action; $\beta = 5.8941$ (ie, $a = 1/6T_c$). Heavy quenched staggered quarks: $m_\pi a = 0.990$ (4) and $m_\rho a = 1.330$ (7); $m_p a = 1.59(5)$.



Tremendous slowing down of CG near critical μ_3: zero modes of Dirac operator.

Correlation functions



Temporal correlators of $\overline{u}\gamma u$ not symmetric in $t \leftrightarrow -t$: hence not eigenstate of transfer matrix.

Transfer matrix eigenstates

Symmetries at $\mu_3 = 0$

Spatial $\otimes$ SU(2). Spatial part includes isometries of the lattice: $t \leftrightarrow -t$ is one part of this. Hence $\overline{u}\gamma u$ and $\overline{d}\gamma d$ are both eigenstates. Pure flavour correlators go as

$$C(t) \simeq \mathrm{e}^{mt} + \mathrm{e}^{-mt}.$$

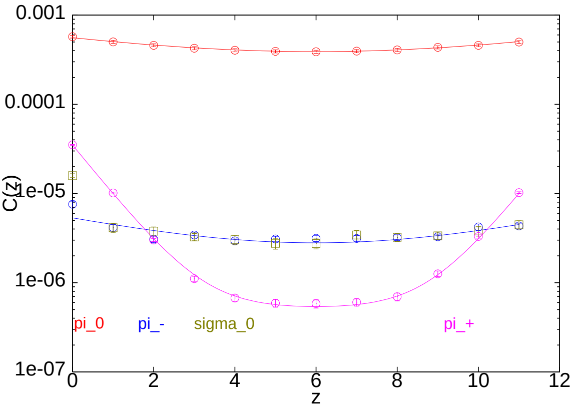
Symmetries at $\mu_3 \neq 0$

SU(2) part broken; $t \leftrightarrow -t$ broken. Combination of the two remains invariant. Hence pure flavour correlators go as

$$C(t) \simeq \mathrm{e}^{mt} + \mathrm{e}^{-m' t},$$

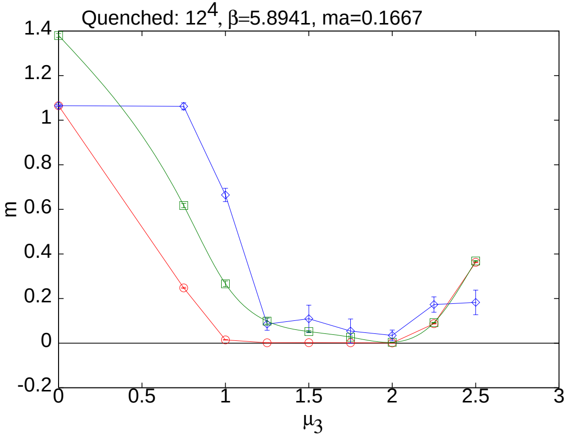
but linear combination of flavours is symmetric under $t \leftrightarrow -t$.

Eigenstates of the transfer matrix



SG, hep-lat/0202005

Physical masses



Some photos from Mumbai

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HAPPY BIRTHDAY

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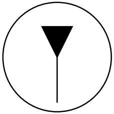

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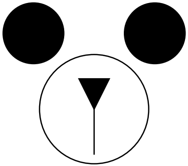

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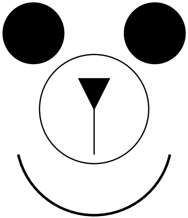

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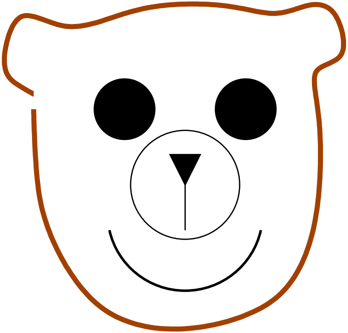

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