O. Borisenko

Devoted to collaboration with G.M. Zinovjev on studying

Deconfinement phase transition in QCD with dynamical quarks: 1986 - 2000

28 common publications ranging from Polyakov-Susslind model for $SU(3)$ QCD to establishing the most general conditions on the fermion Dirac operator for inducing the Chern-Simons term in finite temperature QCD.

In collaboration with: V. Petrov, L. Averchenkova, S. Mashkevich, J. Bohacik, M. Faber.

Triality in QCD

M. Faber, O. Borisenko, G. Zinovjev, Nucl.Phys. B **444** (1995) 563

Action of pure gauge QCD is invariant under global $Z(3)$ transformations. At low temperatures $Z(3)$ symmetry is unbroken. There exists critical point T_c such that for all $T > T_c$ $Z(3)$ symmetry is spontaneously broken. Transition at T_c, where the string tension vanishes, is called deconfinement phase transition. An order parameter - Polyakov loop - measures a free energy F_q of a static quark $\langle P(x) \rangle = \exp[-\frac{1}{T} F_q]$.
Dynamical quarks break $Z(N)$ explicitly and so the whole picture presented above.

Problem: What is and how to describe deconfinement in full theory.
In full theory: 1) string tension is non-zero if $T < T_c$;
2) all physical states have zero triality in QCD;
3) triality is strictly conserved number.
Main idea: Study QCD in the ensemble canonical with respect to triality.
Expected behaviour: The same in both ensembles for $Z(N)$ invariant quantities and different behaviour for non-invariant quantities.

Monte-Carlo simulations confirming the predicted behaviour have been accomplished in a series of papers by S. Kratochvila and P. de Forcrand

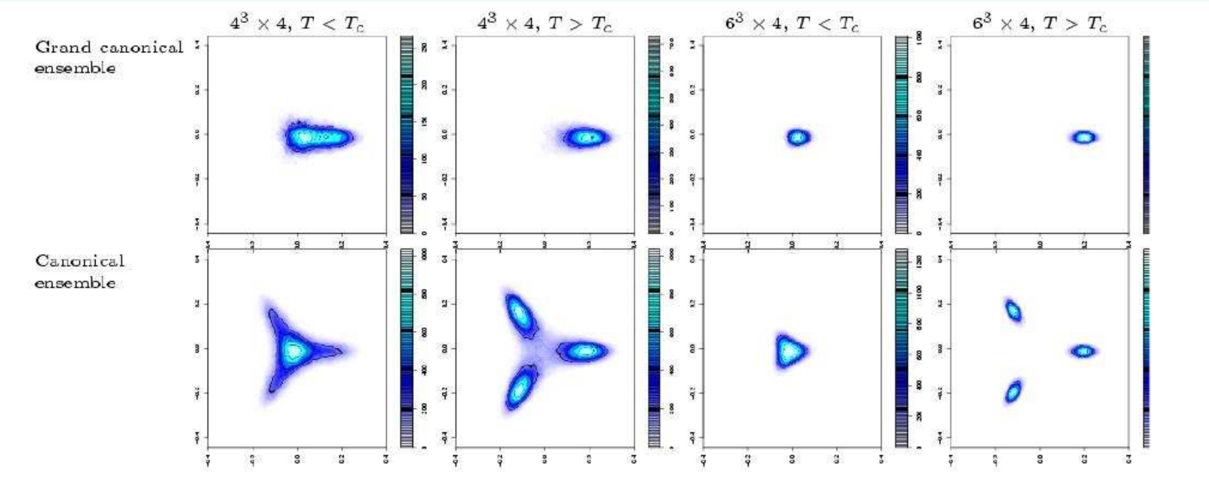

Fig. from Phys.Rev. D **73** (2006) 114512 shows spontaneous breaking of $Z(3)$ global symmetry in the canonical ensemble: distribution of the Polyakov loop in the GCE (top) and in CE (bottom).

Colour screening in a QCD plasma

O. Borisenko, V. Petrov, G. Zinovjev, Phys.Lett. B **236** (1990) 349

Correlation of Polyakov loops give quark–anti-quark potential $V_{q\bar{q}}(R)$

$$\langle P(0)P(R)\rangle - \langle P(0)\rangle^2 = \exp[-V_{q\bar{q}}(R)/T] \ .$$

$$V_{q\bar{q}}(R) \asymp \sigma\, R, \text{ if } T < T_c \ ; \ \ V_{q\bar{q}}(R) \asymp \exp[-m_e\, R], \text{ if } T > T_c \ .$$

Screening mass $m_e(m_m)$ establishes chromo-electric (magnetic) scale in QGP phase. Both masses are well-studied at zero baryon density.

- Problem: How to study m_e, m_m at finite baryon density.
- Main idea: Large N study of Polyakov loop model.
- Results: One of the first calculations of m_e and correlations of real and imaginary parts of Polyakov loops at finite density. Baryon chemical potential increases screening effects.

Order parameter of the deconfinement phase transition

O. Borisenko, M. Faber and G. Zinovjev, hep-lat/9804009

$Z(N)$ invariant order parameter which tests the presence of the N-ality non-invariant states in the full theory

$$A(\Sigma, C) = \frac{\langle\ P(0)F(\Sigma)P(R)\ \rangle}{\langle\ P(0)P(R)\ \rangle\ \langle\ F(\Sigma)\ \rangle} \stackrel{\Sigma, C \to \infty}{\longrightarrow} \exp[\frac{2\pi i}{N} K(\Sigma, C)]$$

$F(\Sigma)$ - 't Hooft loop (disorder operator) winding around the Polyakov loop $P(0)$, $K(\Sigma, C)$ is a linking number of Σ and $P(0)$.

- $K(\Sigma, C) = 0$ - dynamical screening dominates, confinement phase
- $K(\Sigma, C) \neq 0$ - the screening due to gauge fields dominates.
- Operator A works is any gauge theory with fermion and/or Higgs fields.

Deconfinement: a high temperature phase where gluon screening due to chromo-electric mass dominates over dynamical one due to fermion loops

We wish you to celebrate next birthday on Madeira in a company with favorite beverage