Are there really Condensates in QCD?

I will argue, NO.

Particle number violation is too fast

Condensate is non-gauge invariant – at best, large IR occ.

Electric, N-O instab: – at best they cannot be large

Numerical evidence – seems to say NO!

Particle number violation

is efficient! See hep-ph/0209353.

Rate of hard particles hard-splitting: $g^4 T$, same as large-angle elastic rate.

High-occupancy: typical momentum Q, occupancy $f \gg 1$, then $\Gamma_{\rm split} \sim \alpha^2 f^2 Q$, same as large-angle elastic.

Reason: soft scattering with hard splitting.

Soft scatt faster than hard by $(\alpha f)^{-1}$,

collinear radiation costs αf.

Soft particle-violation is even faster!

Braaten Pisarski Phys.Rev.**D42** (1990) 2156
"Calculation of the Gluon Damping Rate in Hot QCD"

Soft gluons, $p < gT$, have $\Gamma \sim g^2 T$. Γ arises from the sum of

"pole-pole, pole-cut, and cut-cut. The pole-pole terms are kinematically forbidden .... The term from a transverse gluon pole plus cut gives $+1.353$; that from a plasmon pole plus cut gives $+2.300$; and the cut-cut term gives $+2.982$."

"Each of these contributions has a direct physical interpretation. The damping rate is the difference between the production and absorption rates for a given particle....The pole-cut contributions come from $2 \leftrightarrow 2$ scattering processes .... The cut-cut terms come from $2 \leftrightarrow 3$ scattering processes."

Gauge invariance

A condensate in a gauge-nonsinglet field is not gauge invariant.

Magnetic screening at ultrasoft scale (where $f \sim 1/\alpha$, which is g^2T near equil): condensate gets scrambled into $p \sim g^2T$ fields, that is, high IR occ rather than exact zero mode.

At best, “condensate” means “large IR occupancies”

Strong-field instabilities

Condensates in the soft-magnetic sector cannot be:
Nielsen-Olesen instabilities.

Electric fields: Schwinger mechanism if E too big.
Need plasmon pair production in time scale $t \sim 1/\omega_{\rm pl}$.
Requires $E > m^2/e$.

So $E < m^2/e$ to avoid Schwinger-mechanism energy loss

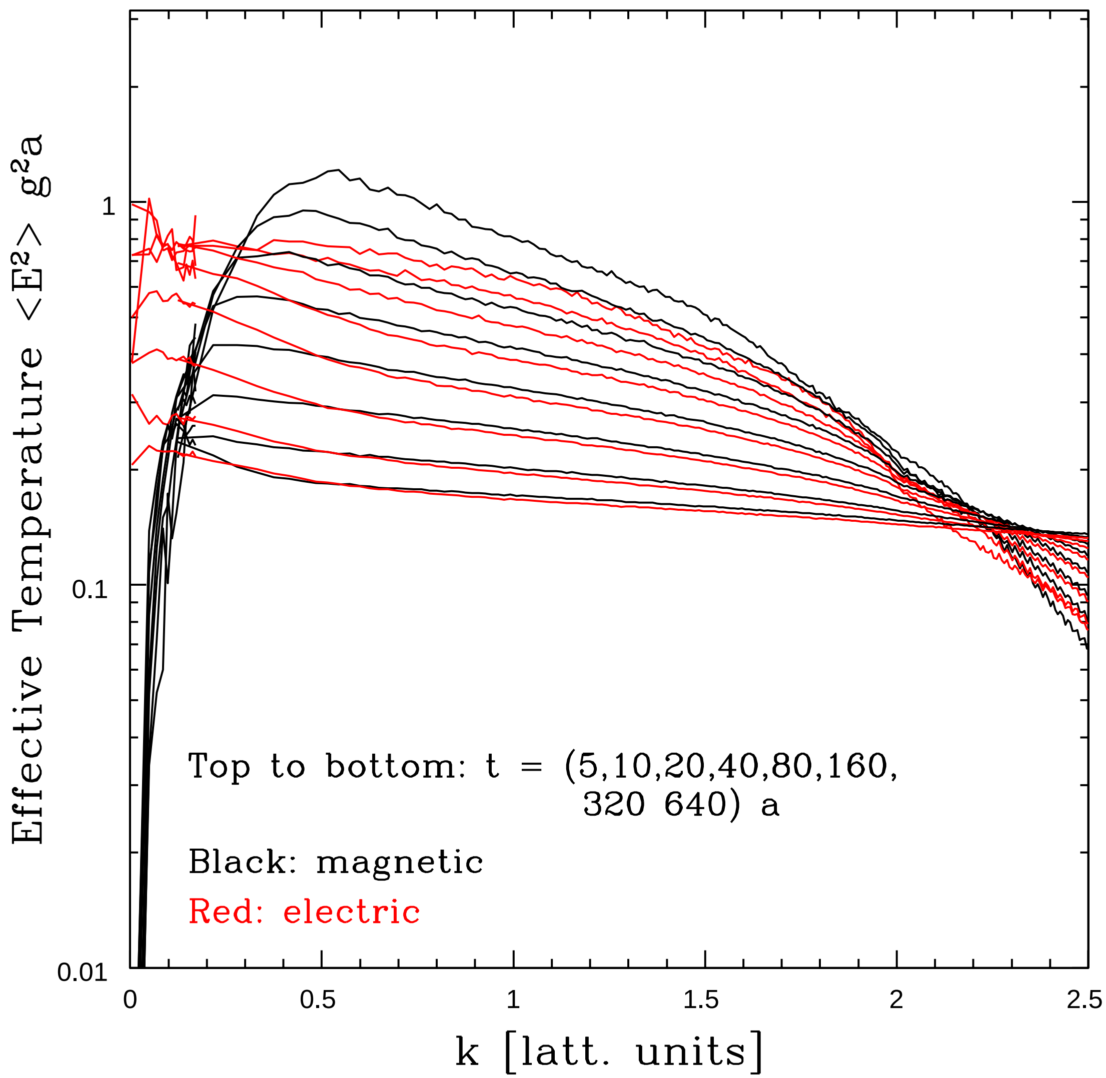
Best reason: I don't see it!

Fixed-box, initial conditions with large IR occupancy and much less in the UV. Classical-field simulations.

Look for E field and A field in Coulomb gauge

$E^2(k)$ is "effective temperature". Condensate means $k = 0$ or very-small-k should have a huge peak in E^2, "higher effective temperature".

$k^2 A^2(k)$ is "effective magnetic temp." Peak would indicate magnetic-condensate. Fall-off indicates magnetic screening, eg, $k^2 \to m^2_{\mathrm{mag}}$.


Effective Temperature <E²> g²a
1
0.1
0.01
0
0.5
1
1.5
2
2.5
k [latt. units]
Top to bottom: t = (5,10,20,40,80,160,
320 640) a
Black: magnetic
Red: electric