Discussion Session

Theory

Talk by Fuqiang Wang

(Phenomenology)

Experiment

Short Overview

Contribution Talks by

Sener Ozonder Massimo D'Elia
Ho-Ung Yee / Tony Rebhan
Kevin Dusling

Talk by

Fuqiang Wang

More Contribution Talks by

Ron Longacre
Edward Shuryak
.....

Theory Questions

on

P- and CP-odd Effects in Hot and Dense (QCD) Matter

Key Issues

Topological objects
Magnetic fields
Non-perturbative methods
Quantitative estimates

Topological Objects

Why is the CME so interesting?

Because the topological contents of the QCD vacuum may be revealed by real experiments.

CME Current

$$j = \frac{e^2 \mu_5 \boldsymbol{B}}{2\pi^2}$$

Anomaly Origin = Exact Relation

Anomaly ← vacuum property

μ_5 ← medium? $\boldsymbol{B}$ ← external?

What is μ_5?

For massless fermions

$$e^{-i\mu_5 t}\psi_R \qquad e^{+i\mu_5 t}\psi_L$$

$U(1)_A$ rotation generating $\theta \sim \mu_5 t$

(c.f. $\chi_{top} = 0$ for $m = 0$)

$$\dot{\theta} \rightarrow \text{CME}$$

$$\vec{\nabla}\theta \rightarrow \text{EDM}$$

How can θ be changing?

No need to require a large $\langle \theta \rangle$ but fluctuations $\langle \delta \theta^2 \rangle$ should be relevant to experiments.

What is the origin of fluctuations?

Topological fluctuations

Euclidean space-time : Topological Susceptibility

Minkowskian space-time : Sphaleron Rate

Magnetic Fields

Strongest (electromagnetic) magnetic fields in the universe.

Affect physics of the strong interactions. How?

CME **(coupling with topological objects)**

Hydrodynamics

(Rotating fluid

c.f. Barnett or Einstein-de Haas effect)

QCD Vacuum Properties

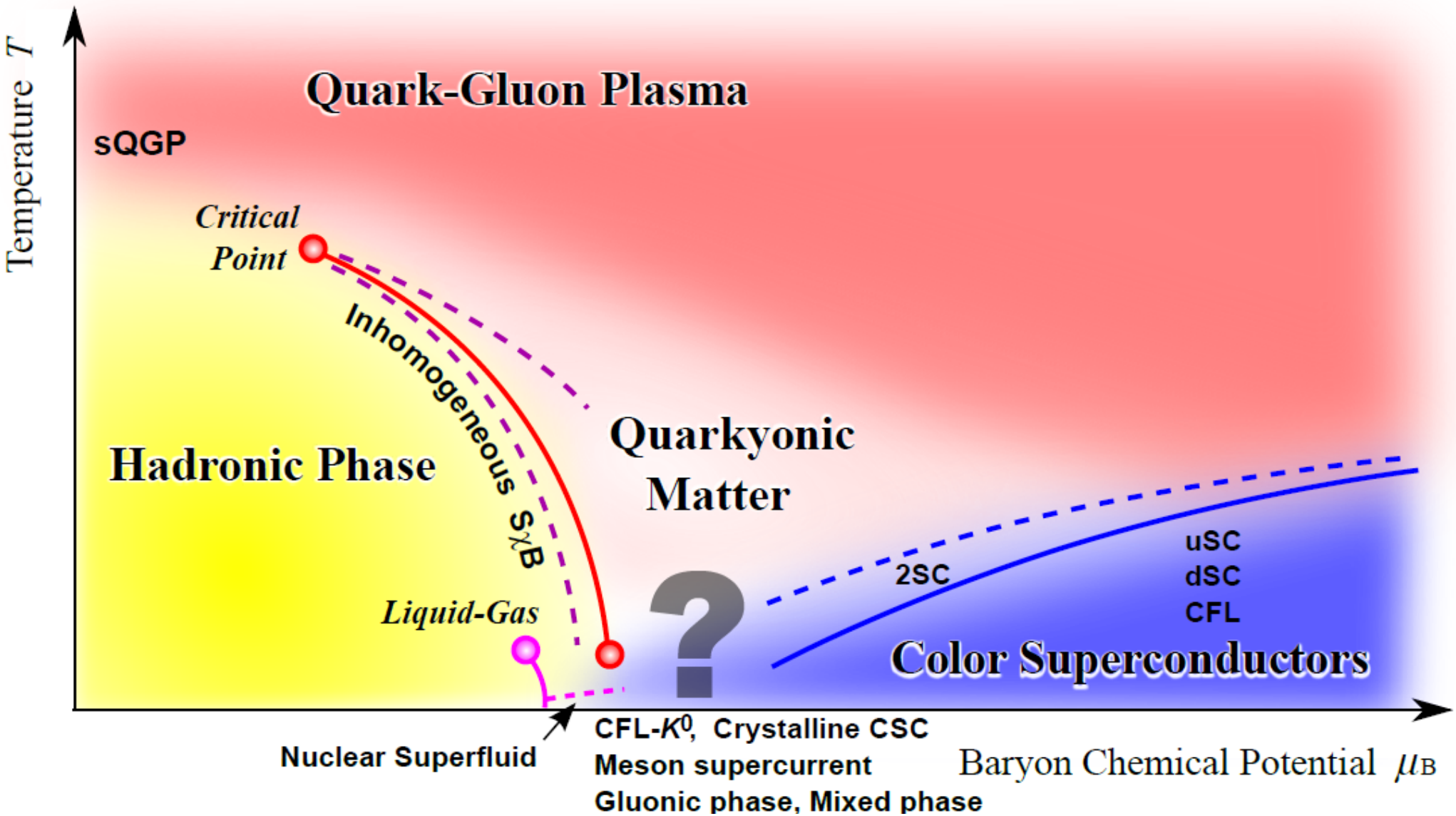
Instabilities **(in-medium)**

Chiral symmetry breaking

(Magnetic Catalysis c.f. de Haas-van Alphen effect)

Confinement ???

QCD Phase Diagram?



Non-perturbative Methods

Lattice QCD Simulation

Holographic Correspondence

Lattice QCD simulation can tell us static properties of the QCD vacuum

CME is not static
Current ← steady state
Useful to understand the vacuum structure

Glasma simulation on the lattice

Classical but real-time simulation
Expansion in the Bjorken coordinates
Topological contents = color flux tube
No fermionic fields...

Holographic Calculations

Analytic continuation from Euclidean to Minkowskian is known.
(In-falling boundary condition at IR)

Many AdS/QCD models...

Some clarification necessary...

Quantitative Estimates

Everything time dependent

Charge asymmetry by $\tau \sim 0.2$fm

(Life-time of B ~ Glasma regime)

How it survives during hydro evolution?

Model to describe data with different $\sqrt{s_{NN}}$, different A, different p_t consistently

Backgrounds or other mechanisms???

$$\langle \cos(\phi_a + \phi_b) \rangle$$
$$\approx (\langle v_1^2 \rangle + B^{\mathrm{in}}) - (\langle a^2 \rangle + B^{\mathrm{out}})$$

Really $B^{\mathrm{in}} \simeq B^{\mathrm{out}}$???

Magnetic fields
Anisotropic medium