# *Baryon-Strangeness Correlations as a diagnostic tool*

*Jørgen Randrup*

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Based on:

*Volker Koch, Abhijit Majumder, and Jørgen Randrup,*
Phys. Rev. Lett. 95 (2005) 182301; nucl/th-0505052

# Ideal quark-antiquark plasma: $u, \bar{u}, d, \bar{d}, s, \bar{s}$

Uncorrelated flavors: $\sigma_{UD}$, $\sigma_{US}$, $\sigma_{DS}$ = 0

$$\begin{cases} U = u - \bar{u} \\ D = d - \bar{d} \\ S = \bar{s} - s \end{cases}$$

$$\boxed{s: \;\; S = -1, B = \tfrac{1}{3}, Q = -\tfrac{1}{3}}$$

=> A(ny) change in *S* induces changes in *B* and *Q*:

$$\begin{cases} \sigma_{BS} = -\frac{1}{3}\sigma_S^2 \\ \sigma_{QS} = +\frac{1}{3}\sigma_S^2 \end{cases}$$

Therefore the correlation coefficients

$$\boxed{C_{BS} \;\equiv\; -3\frac{\sigma_{BS}}{\sigma_S^2}} \quad \text{and} \quad \boxed{C_{QS} \;\equiv\; 3\frac{\sigma_{QS}}{\sigma_S^2}}$$

are *unity* in the ideal plasma (for *any* value of $\mu$ and *T*)

# Ideal hadron gas: $\pi^0, \ldots, \bar{\Omega}^+$

Ideal QGP:

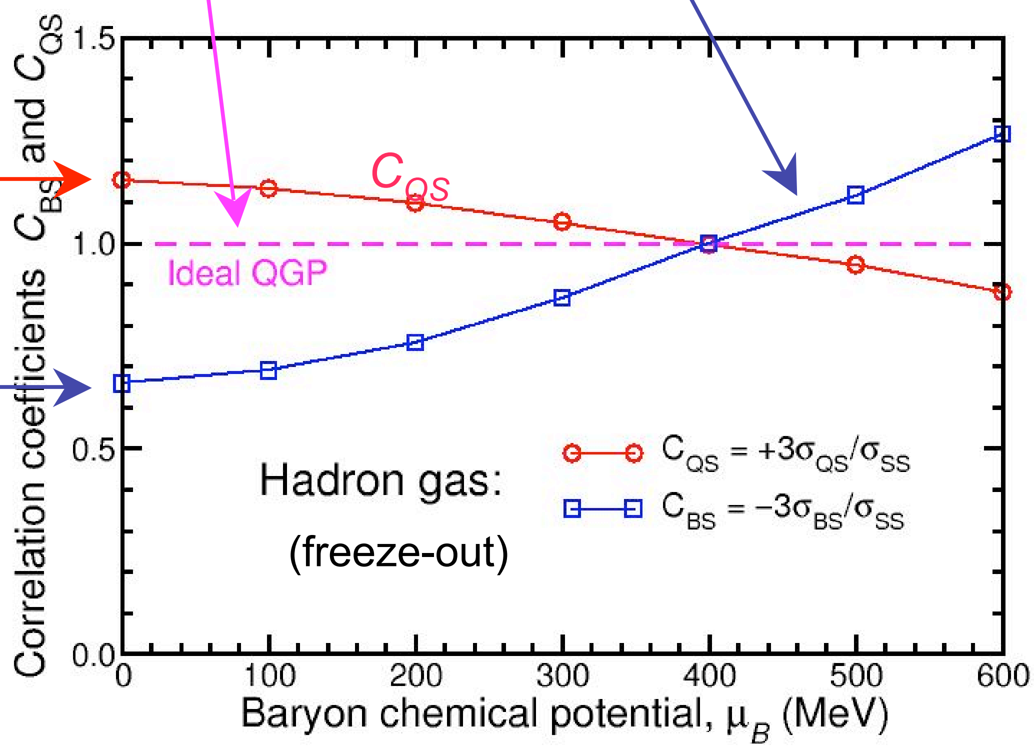
$C_{BS} = C_{QS} = 1$

Ideal hadron gas:

$$C_{BS} \approx 3\frac{\Lambda + \bar{\Lambda} + \ldots + 3\Omega^- + 3\bar{\Omega}^+}{K^0 + \bar{K}^0 + \ldots + 9\Omega^- + 9\bar{\Omega}^+}$$

$C_{QS}(\mu=0) = 1.15$

$C_{BS}(\mu=0) = 0.66$




$C_{BS}(\mu=0) \neq 1$

$dC_{BS}(\mu)/d\mu \neq 0$

# Lattice QCD

*B=(U+D-S)/3:*

$$\sigma_{BS} = \frac{1}{3}\langle[(\overbrace{u-\bar{u}}^{U}) + (\overbrace{d-\bar{d}}^{D}) - (\overbrace{\bar{s}-s}^{S})](\overbrace{\bar{s}-s}^{S})\rangle = \frac{1}{3}[\sigma_{US} + \sigma_{DS} - \sigma_S^2]$$

=> $$C_{BS} \equiv -3\frac{\sigma_{BS}}{\sigma_S^2} = \frac{\sigma_S^2 - \sigma_{US} - \sigma_{DS}}{\sigma_S^2} = 1 - \frac{\chi_{US} + \chi_{DS}}{\chi_{SS}}$$

*Q=(2U-D+S)/3:*

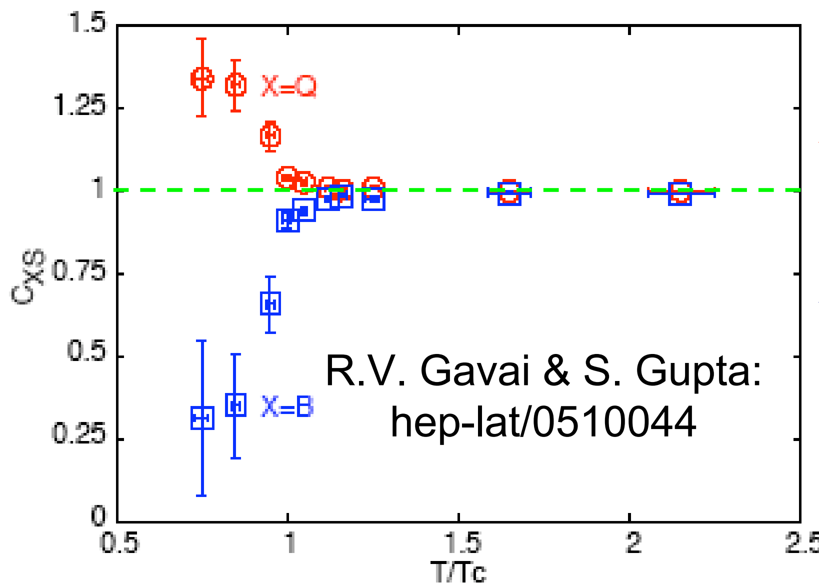
$$\sigma_{QS} \equiv \frac{1}{3}\langle[2(\overbrace{u-\bar{u}}^{U}) - (\overbrace{d-\bar{d}}^{D}) + (\overbrace{\bar{s}-s}^{S})](\overbrace{\bar{s}-s}^{S})\rangle = \frac{1}{3}[2\sigma_{US} - \sigma_{DS} + \sigma_S^2]$$

=> $$C_{QS} \equiv +3\frac{\sigma_{QS}}{\sigma_S^2} = \frac{\sigma_S^2 + 2\sigma_{US} - \sigma_{DS}}{\sigma_S^2} = 1 + \frac{2\chi_{US} - \chi_{DS}}{\chi_{SS}}$$

$$\boxed{\chi_{ff'} = -\frac{\partial^2 F}{\partial\mu_f \partial\mu_{f'}}}$$

Mixed-flavor susceptibilities tend to be small above $T_c$:

$C_{BS} \approx 1$ $C_{QS} \approx 1$




R.V. Gavai & S. Gupta: hep-lat/0510044

$T = T_c$:

≈ 1.15

≈ 0.66

# Bound-state QGP *

* E.V. Shuryak & I. Zahed, Phys. Rev. D70 (2004) 54507:

*Toward a theory of binary bound states in the quark gluon plasma*

749 bound *gq, qq, gg* states, including:

4 $\pi$-like (spin-singlet) *q-sbar* states (and conjugates)

12 $\rho$-like (spin-triplet) *q-sbar* states (and conjugates)

$B = 0$: $\sigma_S$ only: $C_{BS} \downarrow$

18 *sg* states (and conjugates)

Both $B$ & $S$: $C_{BS} \to 1$

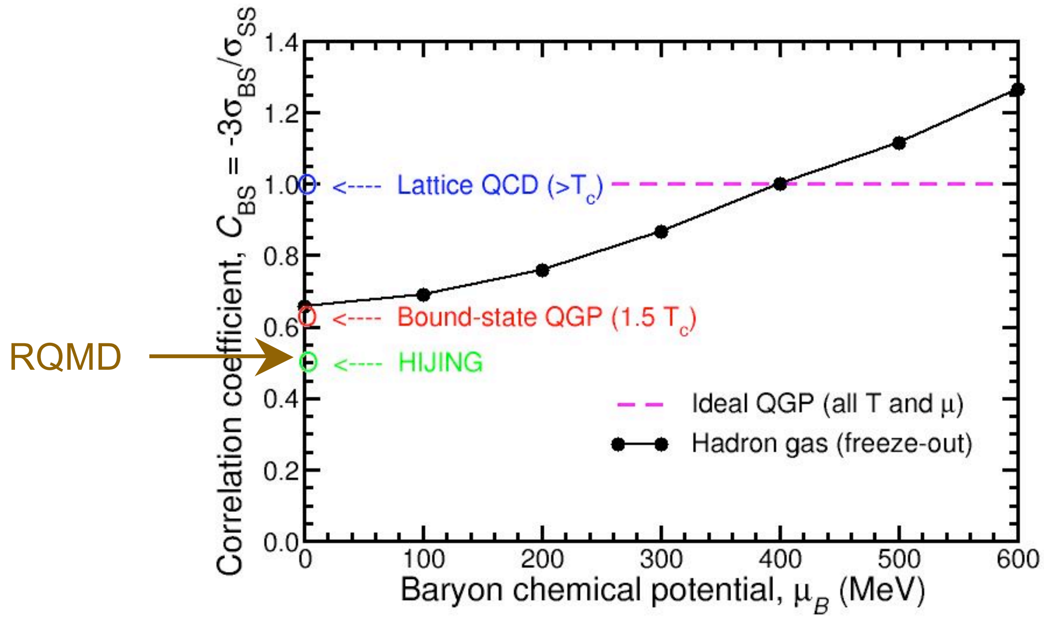
b-s QGP ($T = 1.5\ T_c$): $C_{BS} = 0.62$

*- INconsistent with lattice QCD!*

# Baryon-Strangeness Correlations
# - a sensitive diagnostic tool

$$C_{BS} \equiv -3\frac{\sigma_{BS}}{\sigma_S^2} = 1 - \frac{\chi_{US} + \chi_{DS}}{\chi_{SS}}$$

- can discriminate between models:

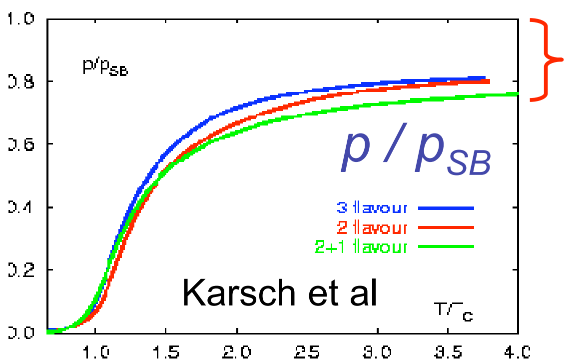



- *and* can be measured via multiplicity fluctuations

# Speculation / conjecture

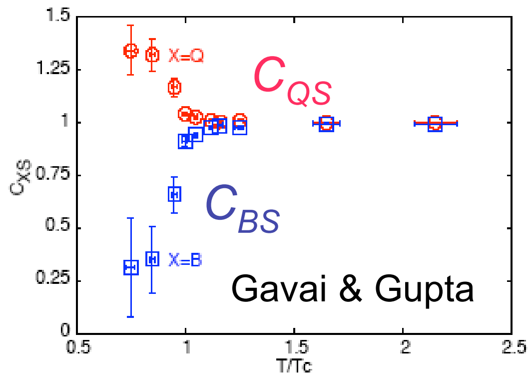
Lattice gauge calculations show that ..

.. the QGP is *not* an ideal quark-gluon gas:




$p < p_{SB}$

.. the quarks and antiquarks in QGP behave as *independent* particles:




?

$$\frac{C_{XS}\text{ (lattice QCD)}}{C_{XS}\ (q\text{-}qbar\text{ gas})} = 1 \qquad (X = B, Q)$$

This apparent inconsistency might be resolved in a *mean-field* picture:

The quark acquires an *effective mass* by the medium: $m\uparrow \Rightarrow p\downarrow$

The associated repulsive interaction may contribute to the *flow*