Some preliminaries

1.D.2

Nuclear Physics **A265** (1976) 315—336;

NUCLEAR COMPRESSIBILITY AND MONOPOLE RESONANCES

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Abstract: Microscopic calculations within the random phase approximation and using self-consistent wave functions show the existence in medium and heavy nuclei of a giant isoscalar monopole resonance which exhausts almost all the energy weighted sum rule. The calculations have been performed with several effective interactions which yield compression moduli ranging from 190 to 356 MeV. It is found that in medium and heavy nuclei the RPA strength function is insensitive to the details of the unperturbed single particle spectrum, and that the energy of the monopole resonance is proportional to the square root of the compression modulus of finite nuclei K_A. This compression modulus is much smaller than the compression modulus of nuclear matter K_∞ because of surface, symmetry and Coulomb effects for which we give numerical estimates. It turns out that K_A is a regular function of K_∞ so that a measurement of the energy of the isoscalar monopole resonance is a possible way of reaching the compressibility of nuclear matter. Recent experimental data suggest a value for the compression modulus of nuclear matter: $K_\infty = 210 \pm 30$ MeV.

1.C

Nuclear Physics **A284** (1977) 429—460; © *North-Holland Publishing Co., Amsterdam*

THEORY OF ELEMENTARY EXCITATIONS IN CLOSED SHELL NUCLEI

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Abstract: We discuss a theoretical approach which allows the calculation of both ground and excited state properties of nuclei in the same framework. The energy of the nucleus, calculated with effective density dependent interactions, is considered as a functional of the one-body density matrix. Starting from this functional, we derive the Hartree-Fock equations for the ground state and the random phase approximation for the excited states. Thus the same effective nucleon-nucleon interaction is used for the ground state and for the excited states: this yields self-consistent effects which are shown to be very important for the properties of the collective states. This approach may be viewed as a microscopic basis for the unified model. A method is developed to solve the RPA equations in the self-consistent basis. It allows the use of any phenomenological form of interaction, in particular finite range ones. We analyse the spin-isospin components in the particle-hole channel of some effective interactions used up to now in ground state calculations; we show that they are well-behaved except for the $\sigma \cdot \sigma$ part which has the wrong sign. Sum rules which connect the static properties of the nucleus to moments of the strength function are calculated and used to check the accuracy of our results. It is shown that it is necessary to use a large configuration space in order to get reliable values of the transition probabilities $B(E\lambda)$. Due to the fact that the only parameters are those of the effective interaction, correlations appear between the calculated values of various quantities, e.g. the value of the $B(E\lambda)$ of low-lying collective states is strongly related to the single particle gap. Some results are presented in order to show the importance of self-consistency.

ELSEVIER

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NUCLEAR
PHYSICS A

Microscopic and macroscopic determinations of nuclear compressibility

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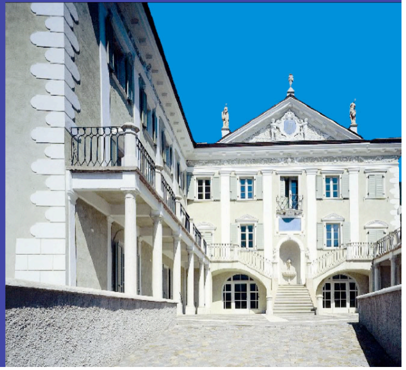
Abstract

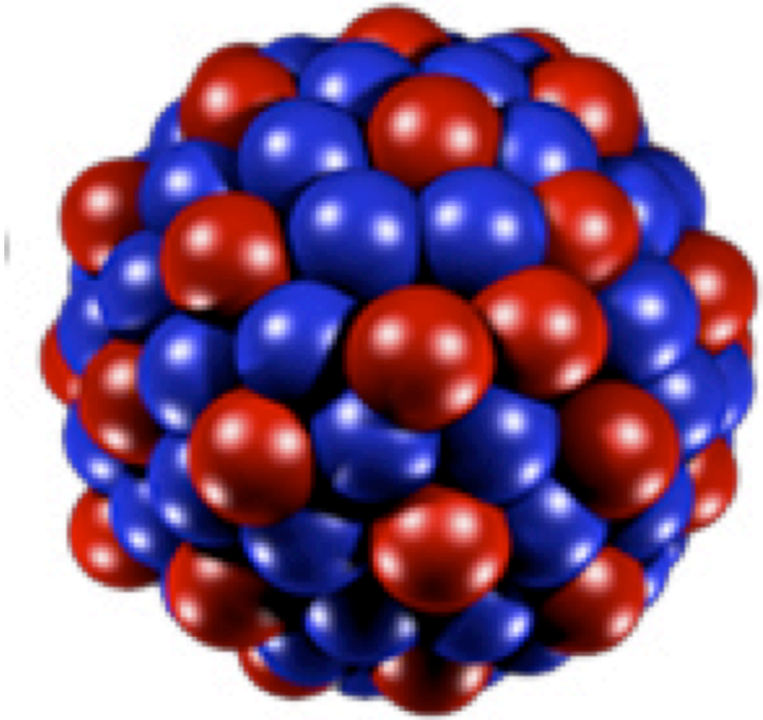
We argue that microscopic calculations remain the most reliable tool for the determination of the nuclear matter compression modulus from the energy of the monopole vibrations of nuclei. Phenomenological expansions of the compression modulus of a nucleus as a function of proton and neutron numbers are ambiguous and cannot yield a precise value for this parameter. Results of new microscopic calculations, with Gogny effective interactions, are presented. These calculations include, in particular, nuclei where pairing correlations are important. They reproduce the available experimental data on heavy nuclei, for a compression modulus in the range 210–220 MeV.

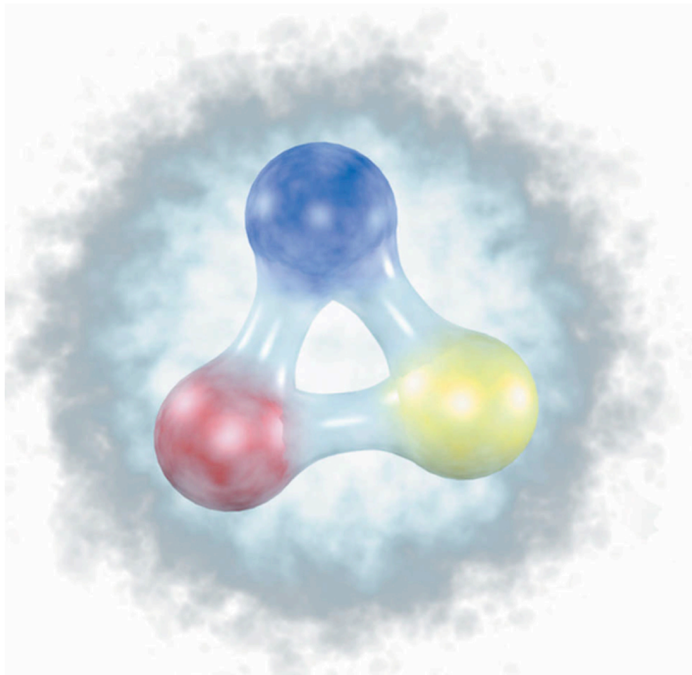
A few topics on hot and dense QCD

Daniel Gogny Jubilee
May 30, 2006

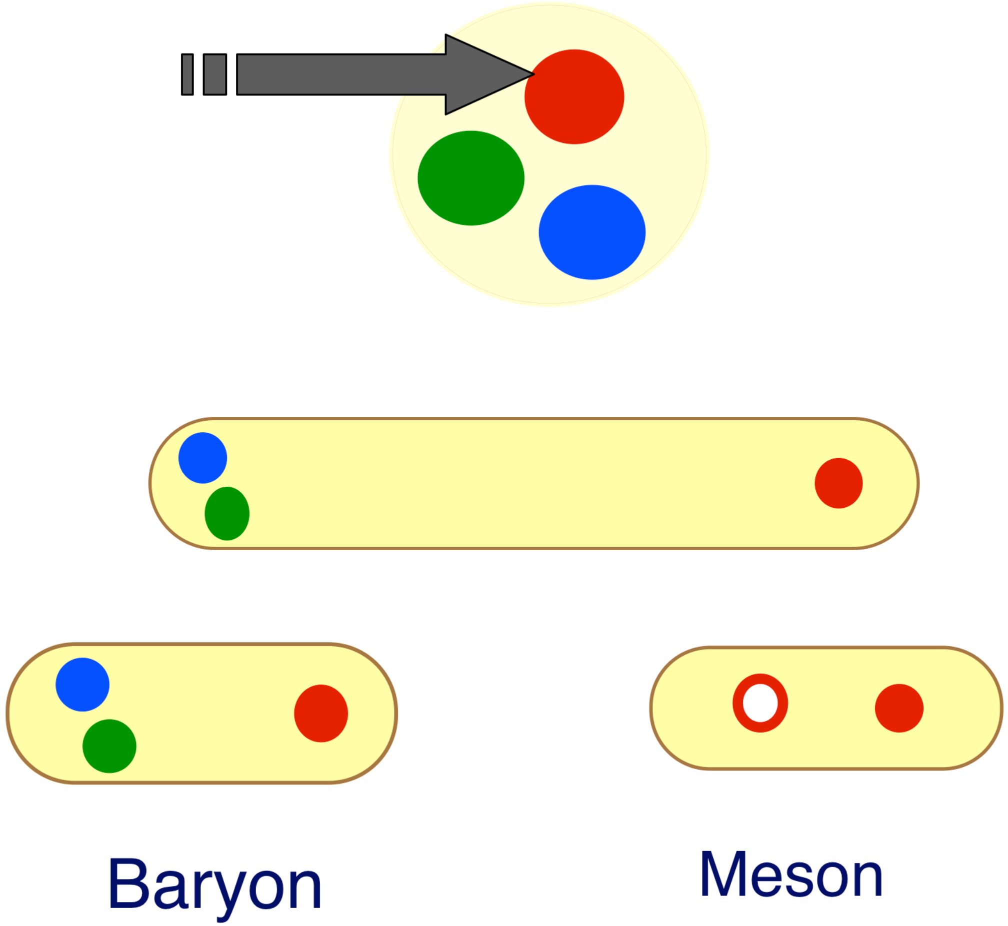
Jean-Paul Blaizot, CNRS and ECT*



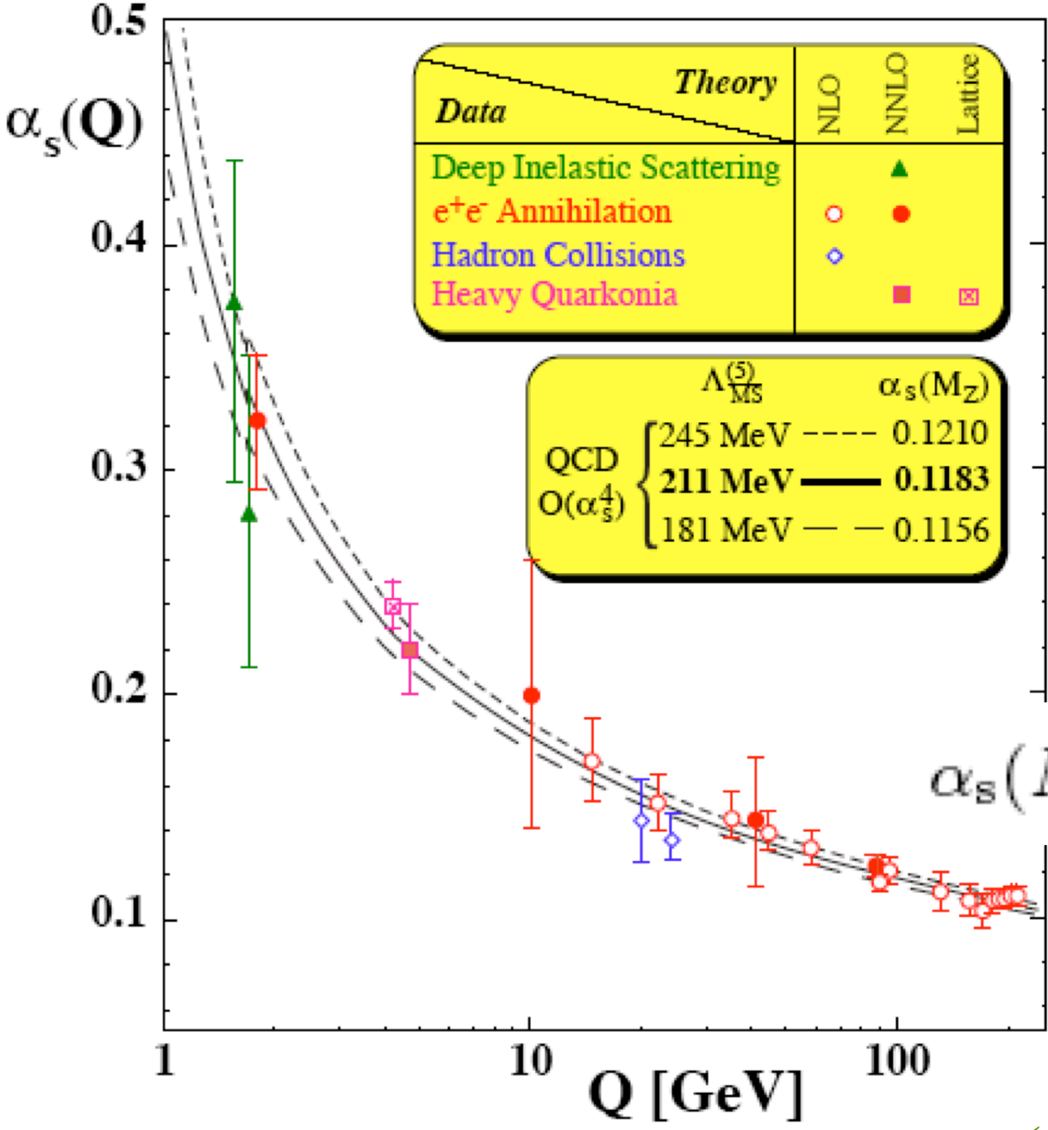




Quarks are confined within hadrons



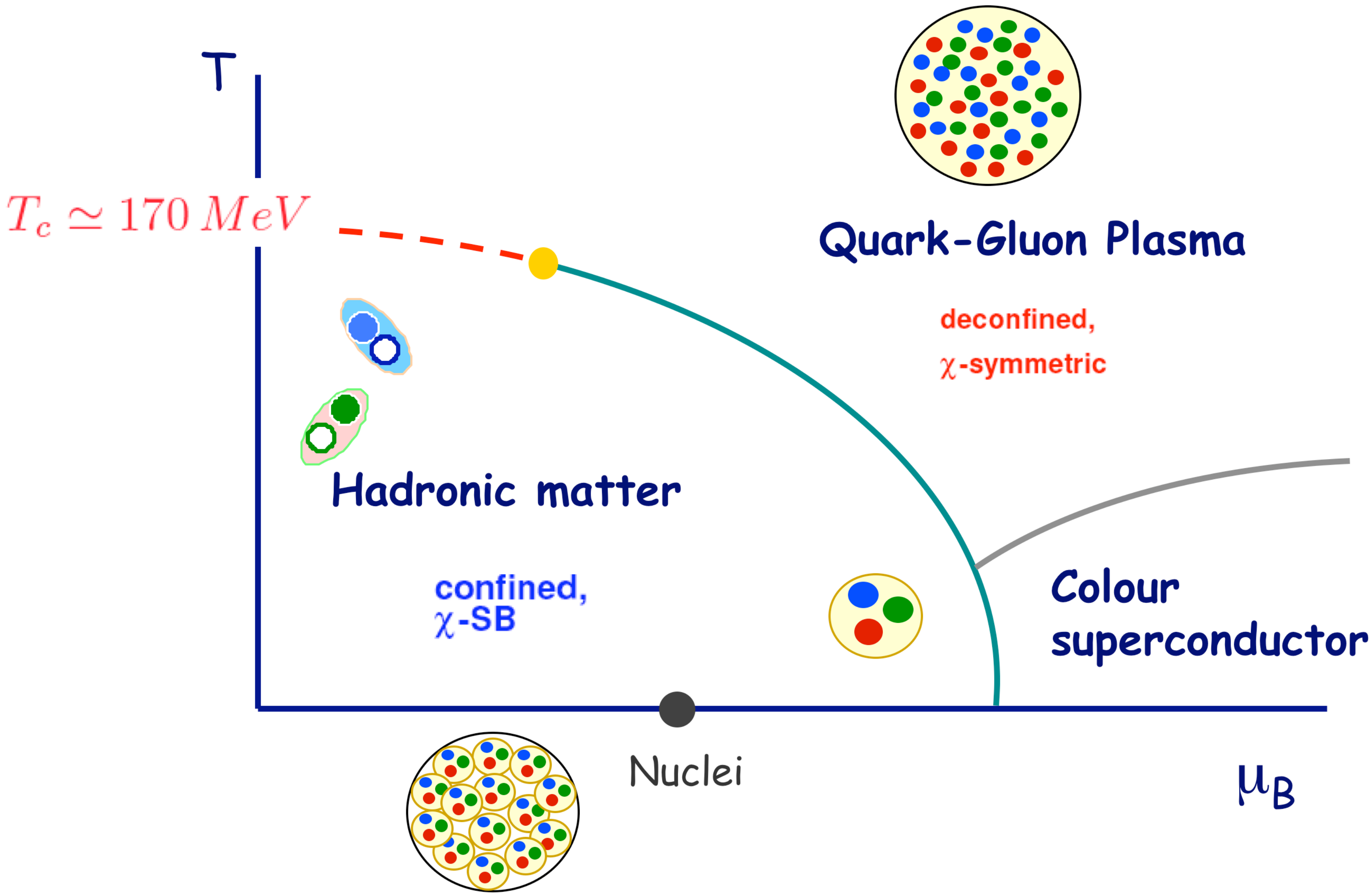
QCD Interactions Weaken at High Energy



$$\alpha_s(M_Z) = 0.1183 \pm 0.002$$

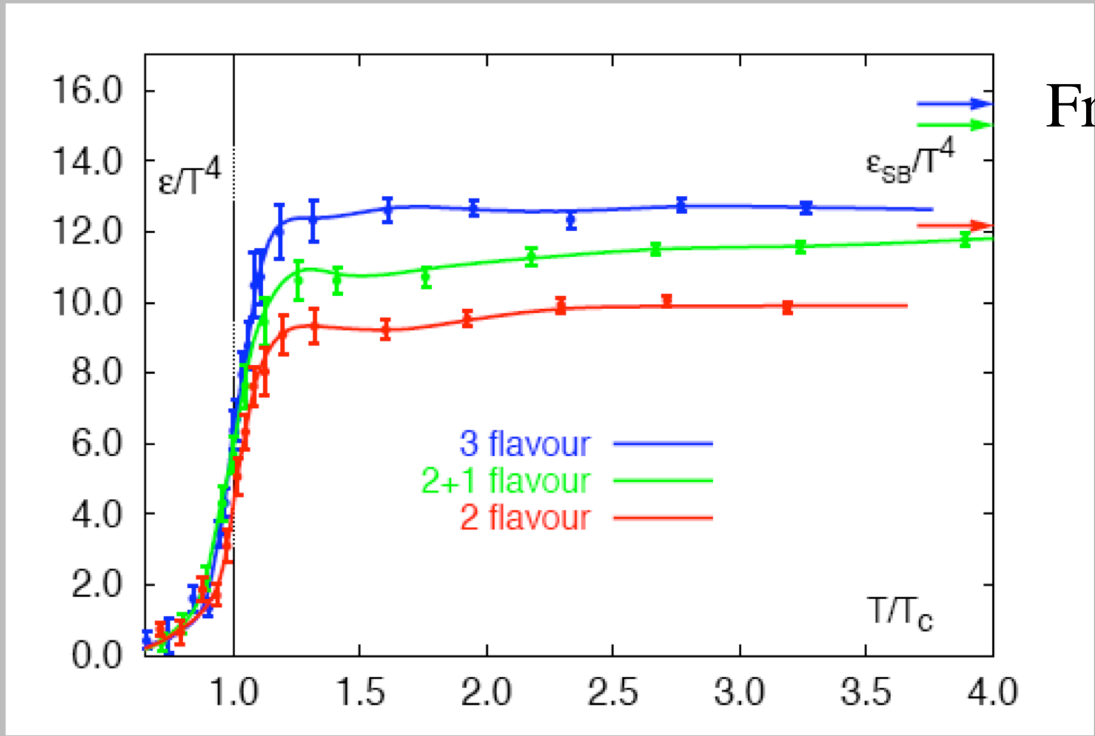
(S. Bethke, hep-ex/021101

The QCD phase diagram



The quark-gluon plasma

Energy density



Free gas limit

Temperature

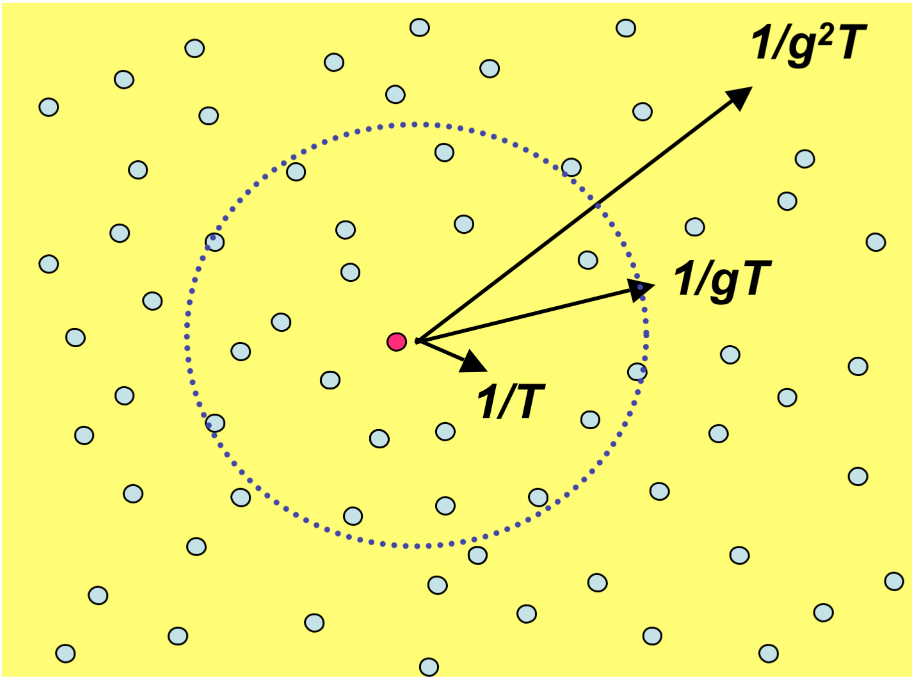
(from F. Karsch, hep-lat/0106019)

QCD plasma $(T >> T_c)$

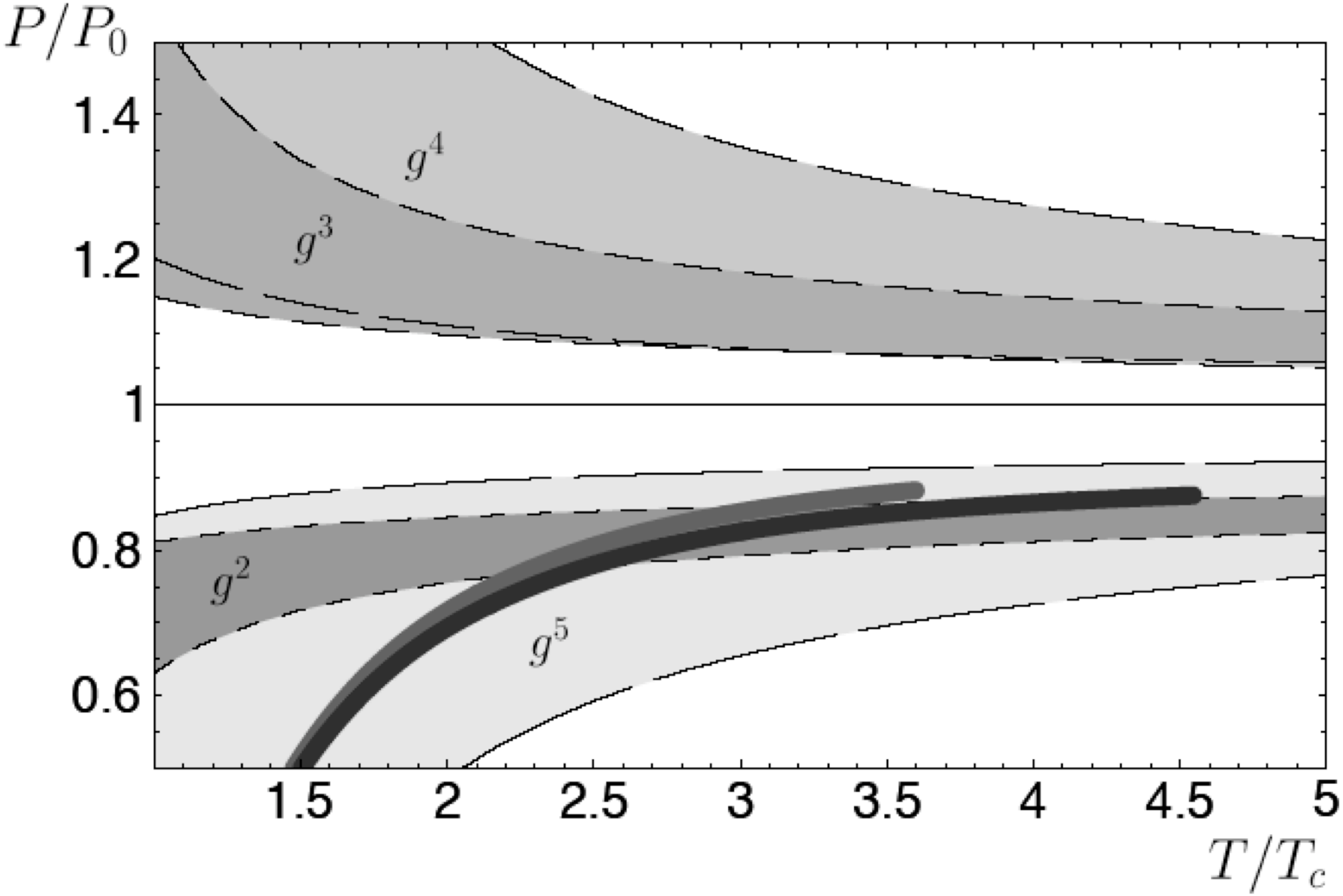
g dimensionless gauge coupling

$$\frac{1}{T} << \frac{1}{gT} << \frac{1}{g^2T} \qquad (g << 1)$$

(interparticle distance) (electric screening) (magnetic screening)



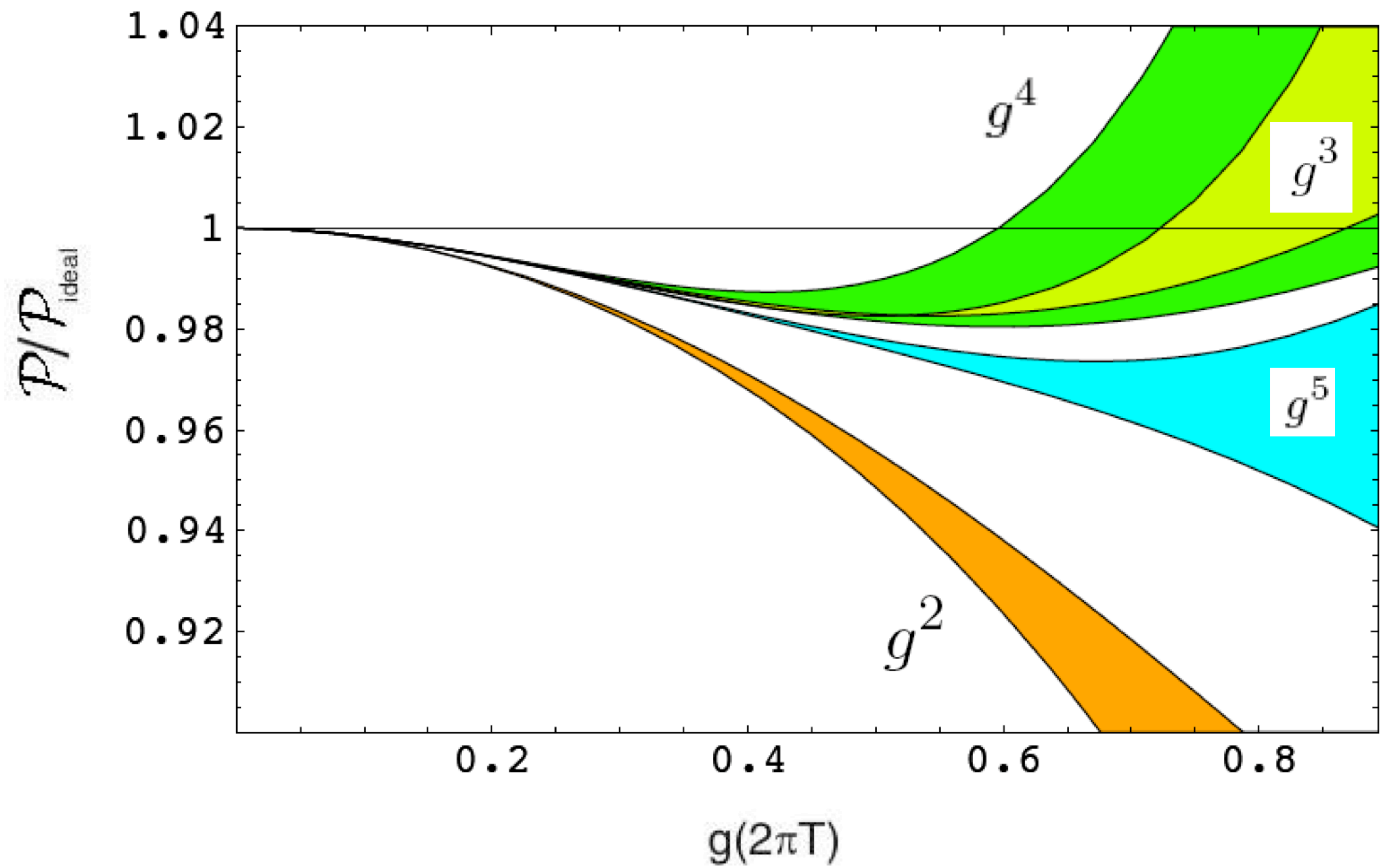
Perturbation theory is ill behaved



A two naive conclusion:

« weak coupling techniques are useless »

Similar difficulty in scalar theory



The bad convergence of Pert. Th. is not related to non abelian features of QCD

Thermodynamic potential

Pressure in terms of dressed propagators

(2PI formalism)

$$P[G]$$

Stationarity property

$$\frac{\delta P}{\delta G} = 0$$

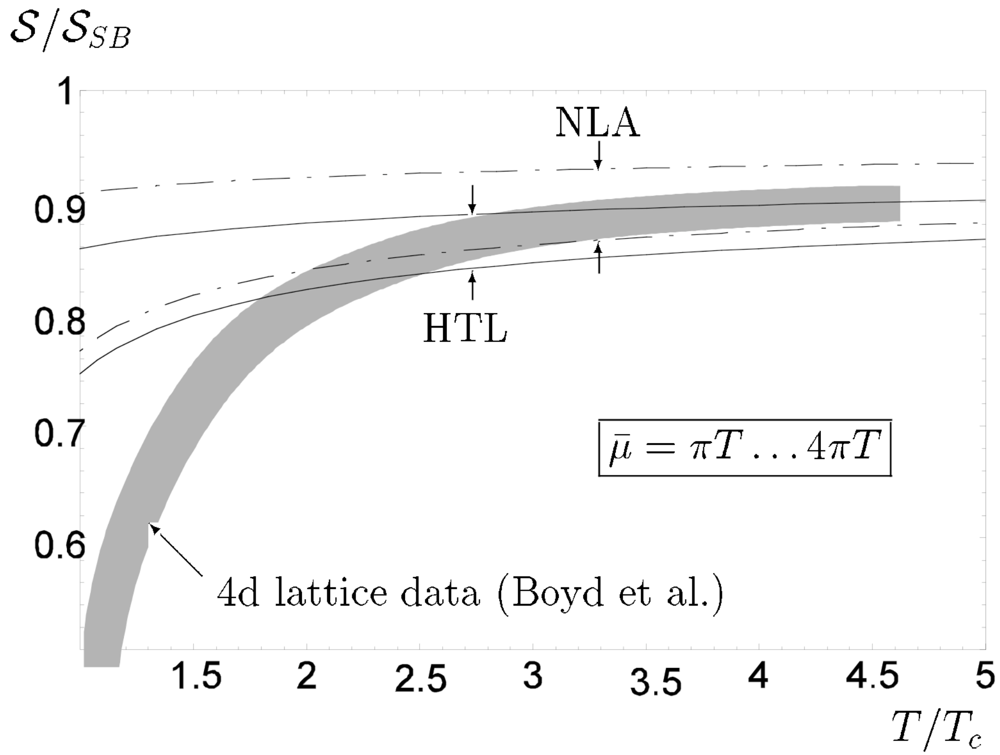
Entropy is simple!

$$S = \frac{dP}{dT} = \left.\frac{dP}{dT}\right|_G$$

State of the art

- Compare Lattice – 2PI

from J.-P. B., E. Iancu, A. Rebhan: Nucl.Phys.A698:404-407,2002



pure-glue SU(3) Yang-Mills theory

- J.-P. B., E. Iancu, A. Rebhan: Phys.Rev.D63:065003,2001
- F. Karsch, Nucl.Phys.A698:199-208,2002;
- G. Boyd *et al.*, Nucl. Phys. B469, 419 (1996).

Region above Tc not well understood

$$T_c \le T \le 2.5 T_c$$

Degrees of freedom ?

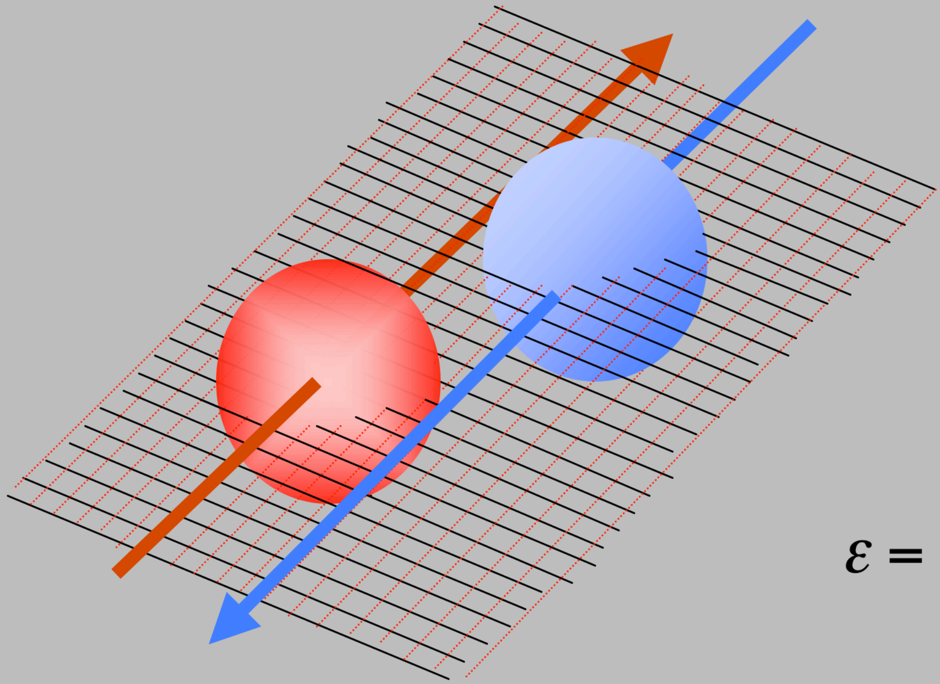
Remnants of confinment ?

Strong coupling phenomena ?

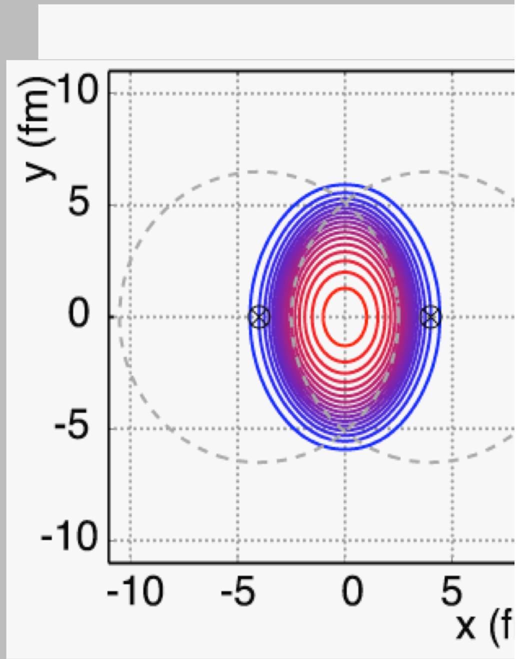
Analogies with other systems (Super Yang Mills,
Cold atoms near a Feschbach resonance)

Produced particles flow preferentially in the reaction plane

(J.-Y. Ollitrault, 1992)



$$\varepsilon = \frac{\langle y^2 - x^2 \rangle}{\langle y^2 + x^2 \rangle}$$

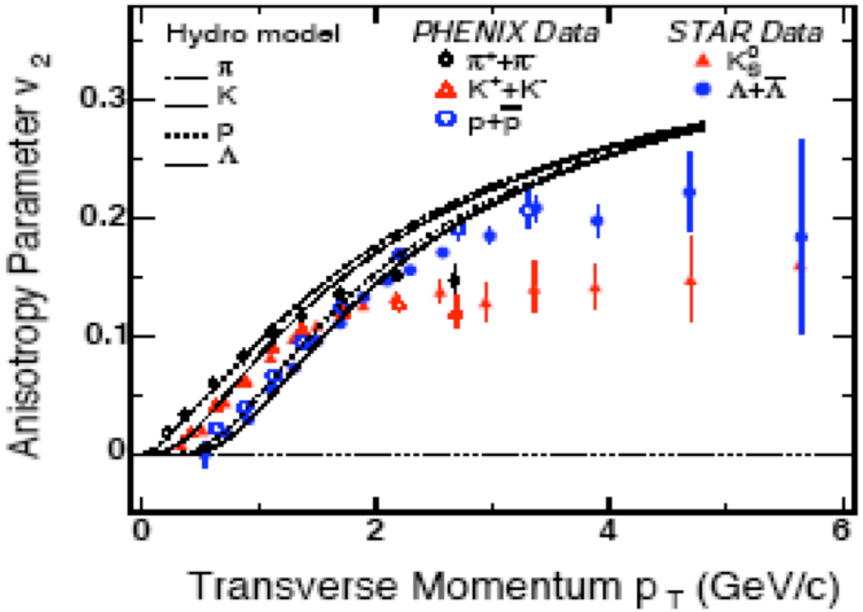


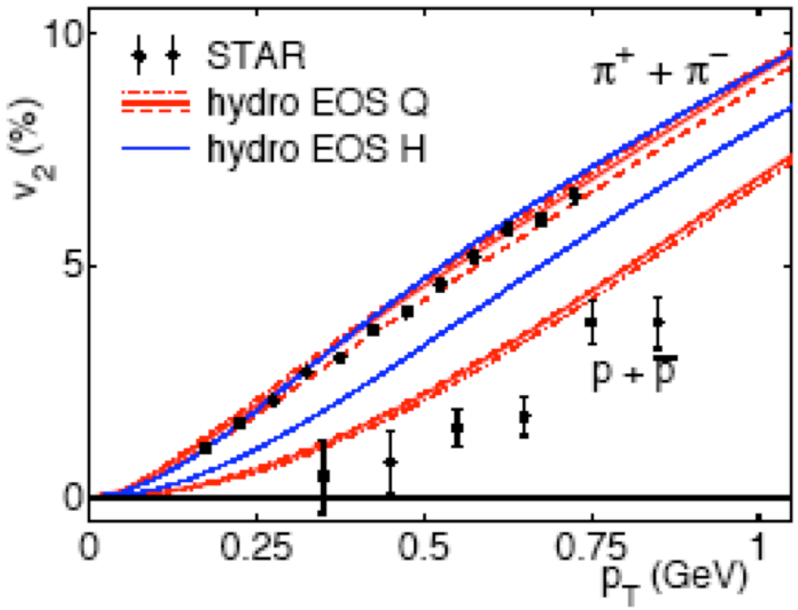
$$V_2 = \langle \cos(2\varphi) \rangle$$

(S. Voloshin and Y. Zhang, 1994)

(P.F. Kolb, J. Sollfrank and U. Heinz, PRC 62 (2000) 054

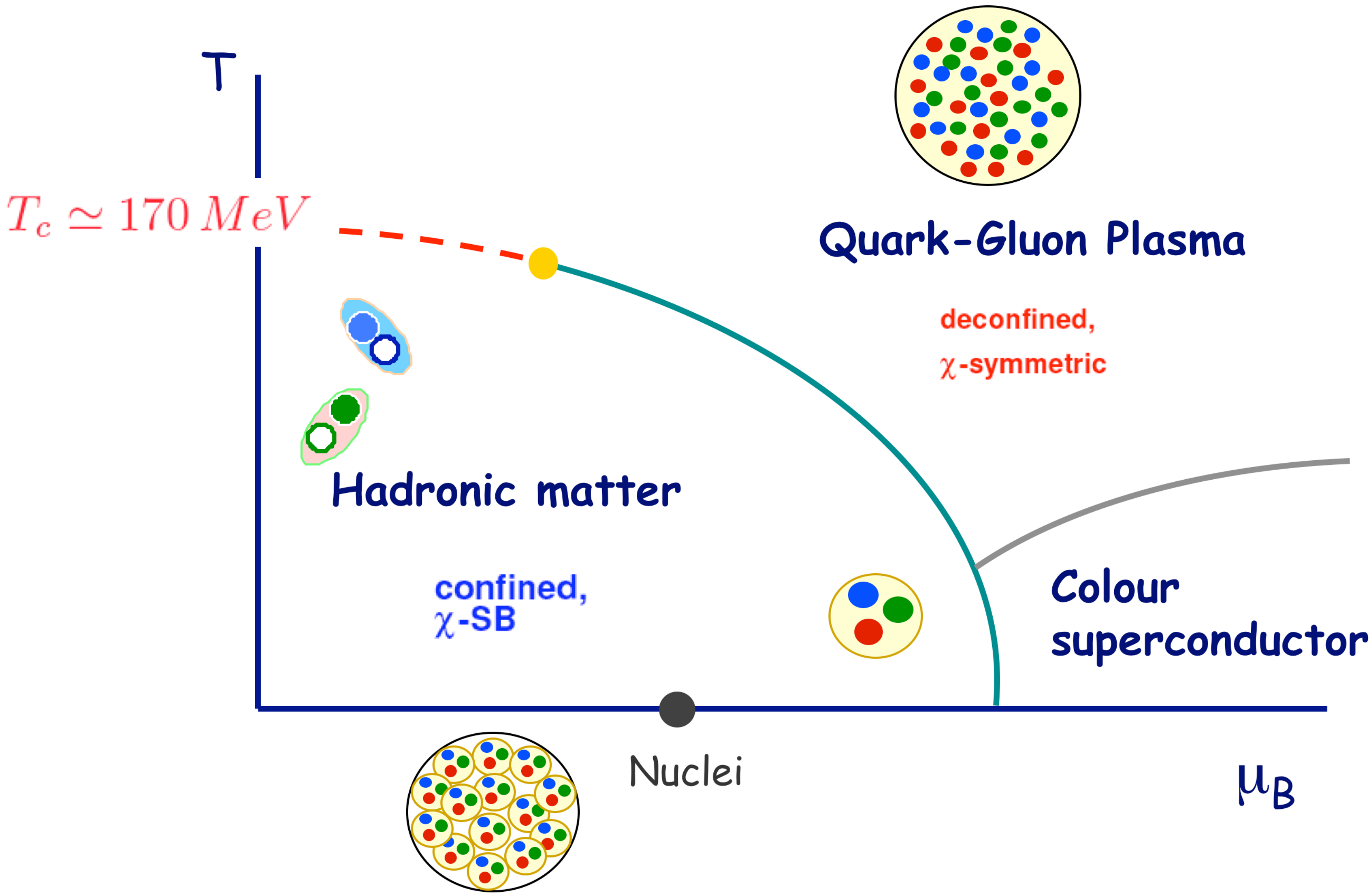
Comparison with hydrodynamics





(From U. Heinz, nucl-th/0412094)

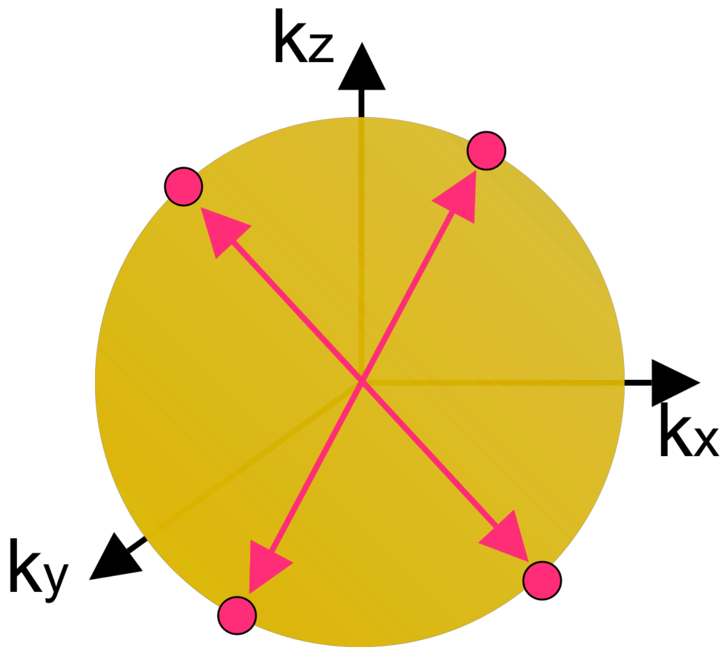
The QCD phase diagram



BCS-BEC crossover

Eagles,(1969); Leggett, (1980),Nozieres and Schmitt-Rink (1985)

BCS

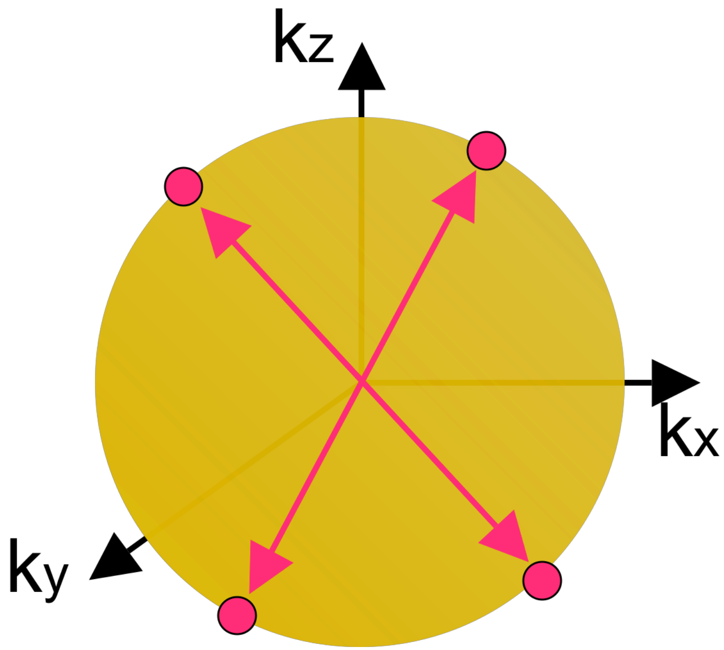


Condensation of
Cooper pairs

BCS-BEC crossover

Eagles,(1969); Leggett, (1980),Nozieres and Schmitt-Rink (1985)

BCS

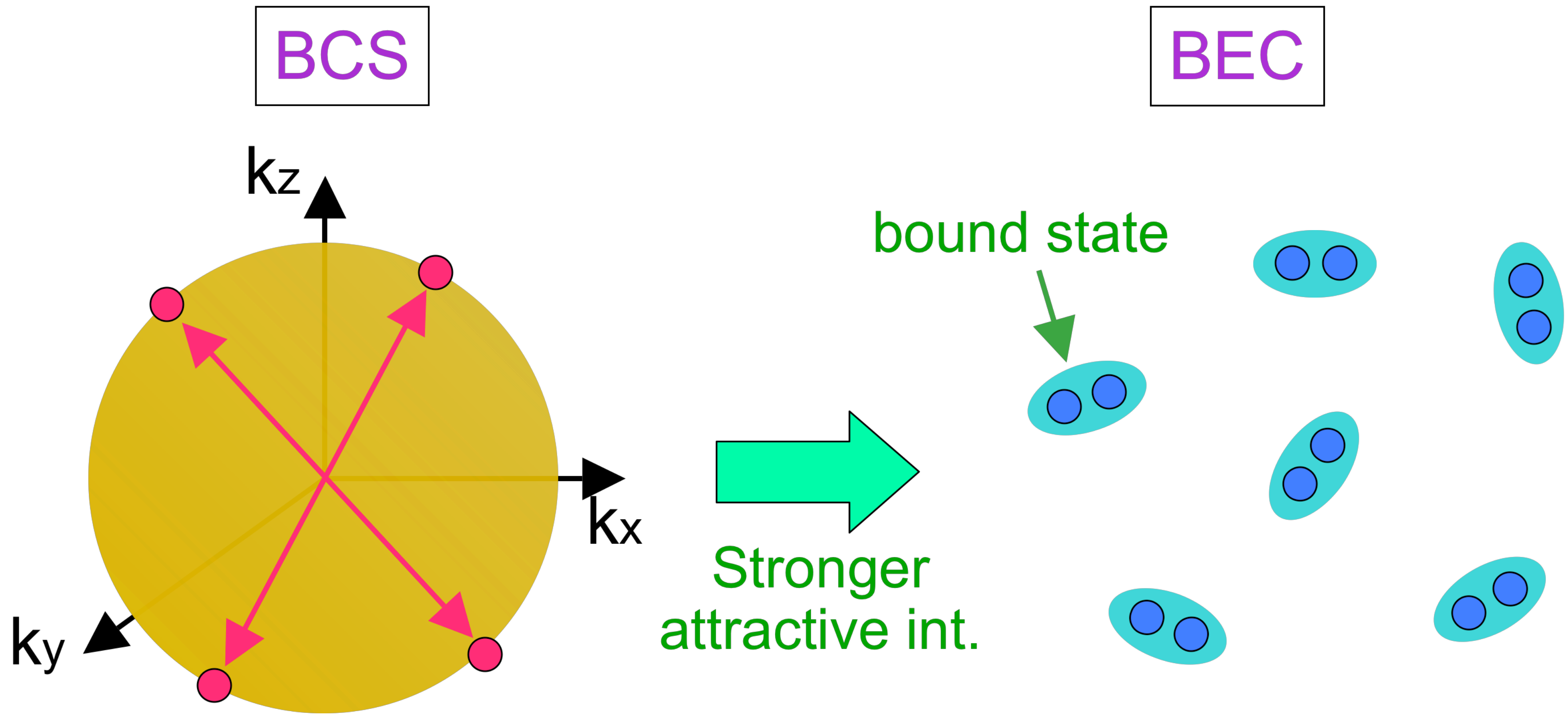


Stronger attractive int.

Condensation of
Cooper pairs

BCS-BEC crossover

Eagles,(1969); Leggett, (1980),Nozieres and Schmitt-Rink (1985)



Condensation of
Cooper pairs

Bose-Einstein Condensatio
of bound bosons