The Search for the Critical Point

Lattice QCD calculations show that in a matter-antimatter symmetric environment the transition between a gas composed of mesons and baryons to the QGP occurs smoothly as a function of increasing temperature, with many thermodynamic properties changing dramatically but continuously within a narrow temperature range. In contrast, if nuclear matter is squeezed to higher and higher densities without heating it significantly—a feat accomplished in nature in the cores of neutron stars (see Box 2.4)—sharp phase transitions (as in the boiling or freezing of water) may result. A map of the expected QCD phase diagram (Figure 2.25) predicts that the continuous crossover currently being explored in heavy-ion collisions at the highest RHIC energies will become discontinuous if the excess...
Phase diagram of QCD → Think in terms of bags

Simplest version of bag model:
- Complicated vacuum fields in free space ("nonperturbative") → recall video
- Hadrons are color singlet "bags" excluding (or reducing) these fields
- Massless quarks in empty (perturbative) vacuum inside bag → kinetic energy
- Energy density difference $B$ exerts inward pressure ($B \approx 200$ MeV/fm$^3$)
- Minimize $E(R)$ to find hadron mass
Cold QGP

MIT Bag

"Big Bag"

Equation of state
MIT bag model

\[ \varepsilon (\rho_B) = \left( \frac{3}{2} \right)^{7/3} \left( \frac{3}{2} \right)^{2/3} \rho_B^{4/3} + B \]

\[ p (\rho_B) = \frac{1}{3} \left( \frac{3}{2} \right)^{7/3} \left( \frac{3}{2} \right)^{2/3} \rho_B^{4/3} - B \]

quarks vacuum
• At high baryon density and low temperature, baryon bags overlap and dissolve $\rightarrow$ phase transition
• At low baryon density but high temperature, pions in hadron gas fill space, overlap and dissolve $\rightarrow$ phase transition