Vista

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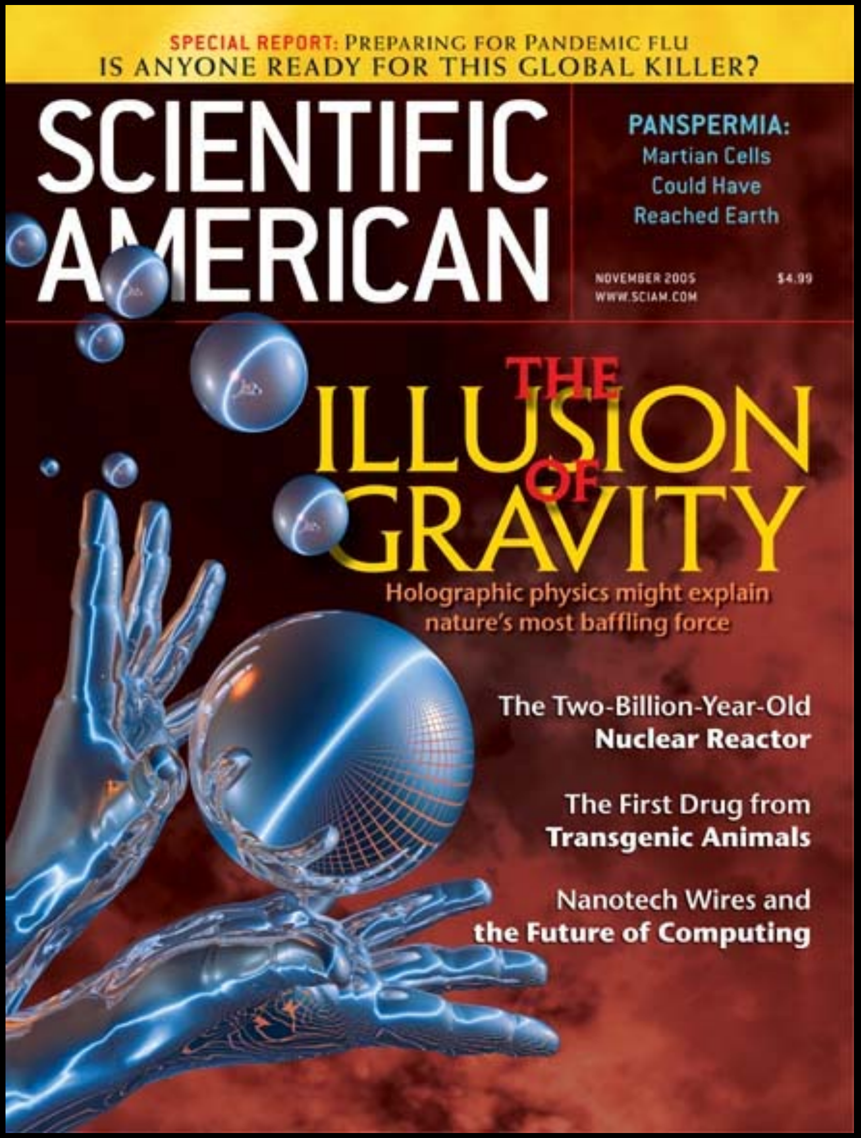
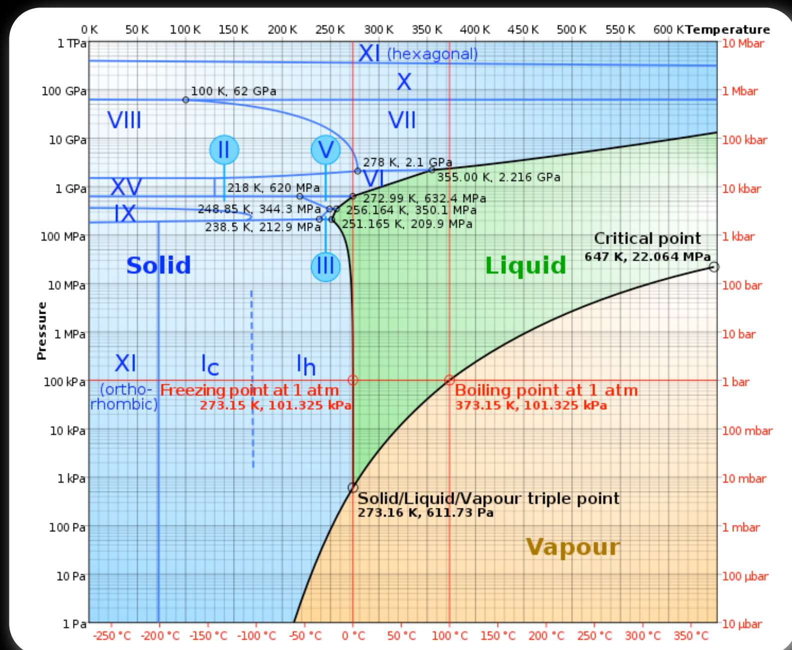
What happens when you heat and compress matter to very high temperatures and densities?

- Lattice QCD predicts a phase transition to a quark gluon plasma at an energy density of about 1 GeV/fm^3 and at a temperature of about ~10^{12} K
    - study in the laboratory!
- From this study we learn about:
    - multi-body QCD at strong coupling
        - connection to AdS/CFT
    - Cosmology: early universe, hadronization
    - Astrophysics: neutron stars

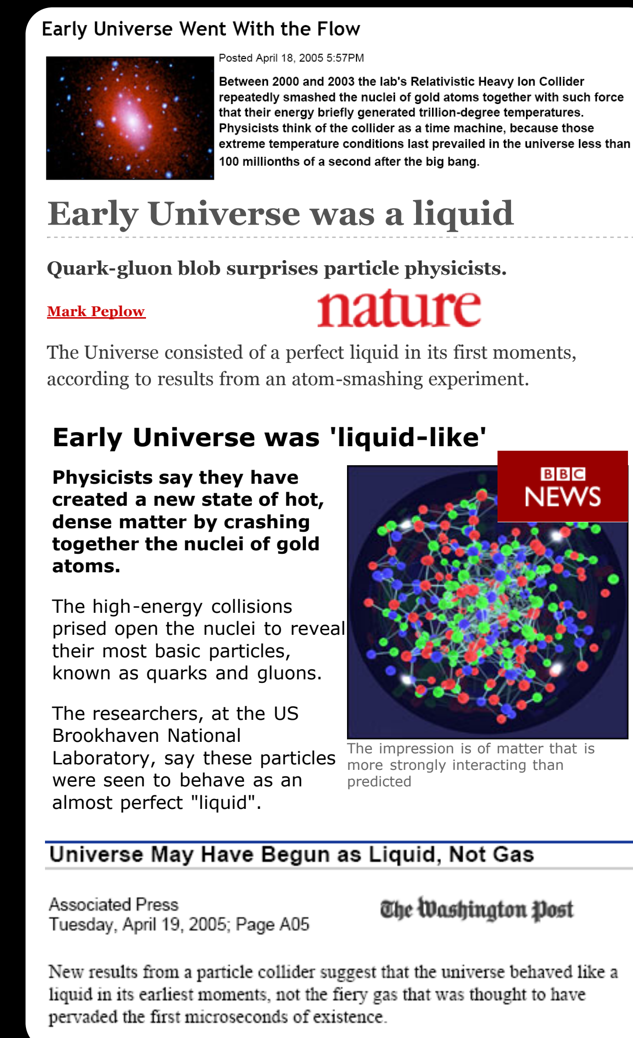


our current understanding of this new state of matter is still limited!

QCD Phase Diagram



phase diagram of water



Early Universe Went With the Flow

Posted April 18, 2005 5:57PM

Between 2000 and 2003 the lab's Relativistic Heavy Ion Collider repeatedly smashed the nuclei of gold atoms together with such force that their energy briefly generated trillion-degree temperatures. Physicists think of the collider as a time machine, because those extreme temperature conditions last prevailed in the universe less than 100 millionths of a second after the big bang.

Early Universe was a liquid

Quark-gluon blob surprises particle physicists.

Mark Peplow

nature

The Universe consisted of a perfect liquid in its first moments, according to results from an atom-smashing experiment.

Early Universe was 'liquid-like'

Physicists say they have created a new state of hot, dense matter by crashing together the nuclei of gold atoms.

The high-energy collisions prised open the nuclei to reveal their most basic particles, known as quarks and gluons.

The researchers, at the US Brookhaven National Laboratory, say these particles were seen to behave as an almost perfect "liquid".

BBC NEWS

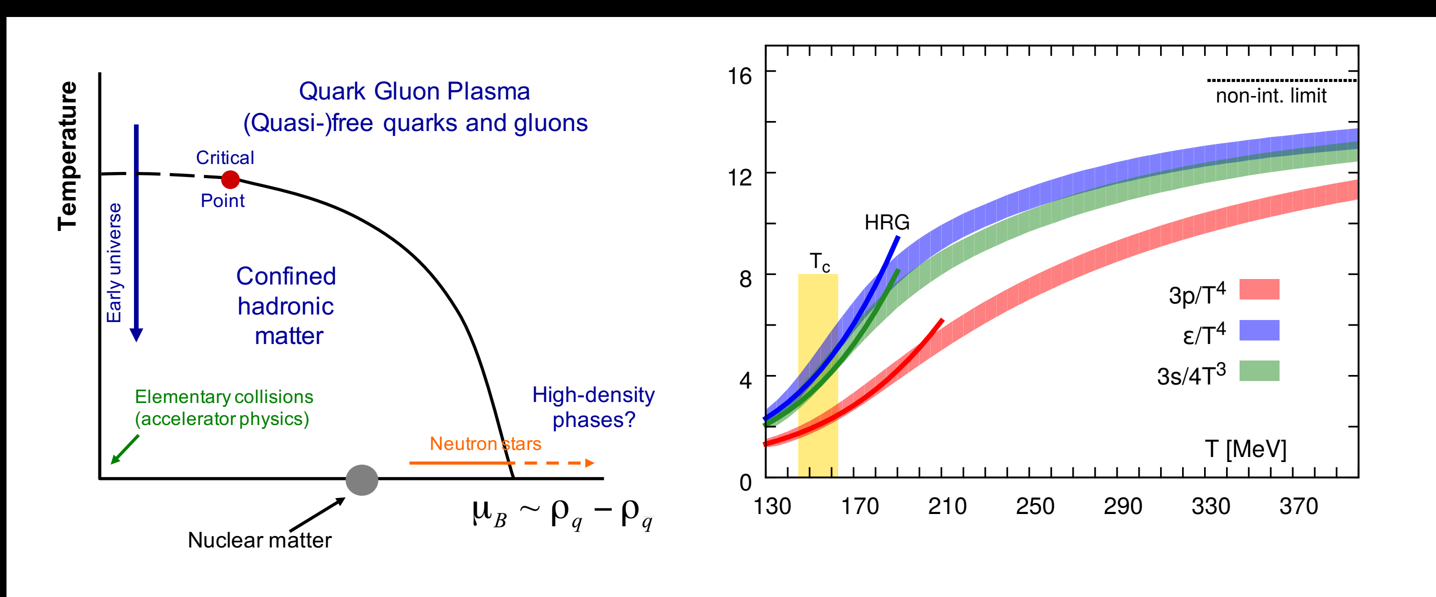
The impression is of matter that is more strongly interacting than predicted

Universe May Have Begun as Liquid, Not Gas

Associated Press
Tuesday, April 19, 2005; Page A05

The Washington Post

New results from a particle collider suggest that the universe behaved like a liquid in its earliest moments, not the fiery gas that was thought to have pervaded the first microseconds of existence.



paradigm change: matter at almost zero net baryon density exhibits a cross over transition and a strongly interacting almost perfect liquid emerges for which we currently have a “standard” model of its evolution (combined experimental and theoretical effort)

LHC, RHIC BES, new facilities

Questions we would like to answer in the ALICE program

- We would like to characterise this complex almost perfect liquid (EoS, transportparameters) and understand how it emerges from multibody QCD (quasi-particles, fields, …)
  - how does a weakly coupled system evolve into a strongly coupled system very quickly (which can be described by relativistic viscous magnetohydrodynamics)?
  - how does the formation of this system depend on system size?

- Why at the LHC?
  - in this regime lattice QCD calculations under control for thermodynamic properties (providing the much needed theoretical guidance)
  - latest generation of detectors, hard probes (jets and heavy quarks) abundantly produced

Future LHC Program

upgrade to full energy
10 x more data

increase in luminosity
10x

high luminosity LHC
100 x more data

LS1
2014

LS2
2019-2020

LS3
2024-2026

2015-2018

goals:
jet, dijets, γ-jet, Z-jet
differentially versus centrality, flow plane, pid
multi-particle correlations, v_n correlations
parton transport and energy loss (jets, heavy-flavor)
color screening quarkonia
low-mass di-leptons, ρ-spectral function, thermal photons
saturation, low-x
collectivity in pA

2021-2023

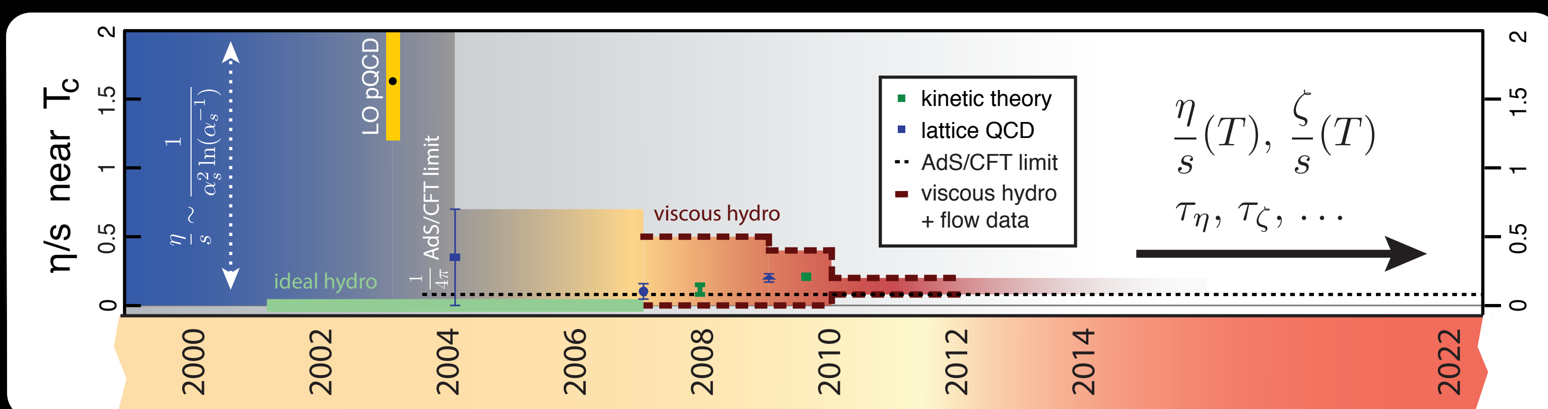
2026-
runs:
pA, PbPb, ArAr

goals:
jet, dijets, γ-jet, Z-jet, W-jet
differentially versus centrality, flow plane, pid
parton transport and energy loss (jets, heavy-flavor)
color screening quarkonia
low-mass di-leptons, ρ-spectral function, thermal photons
saturation, low-x (new detector?)
t-tbar in heavy-ions

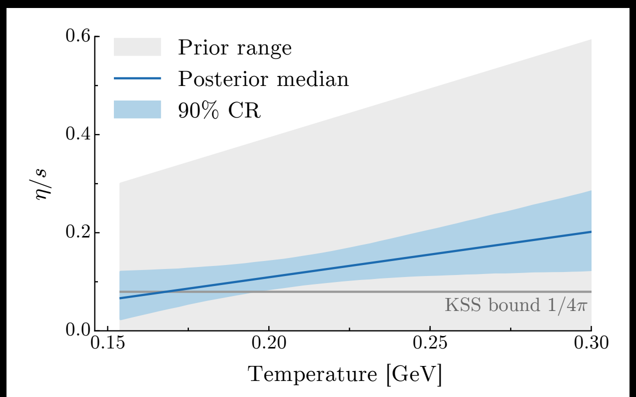
Key future measurements to test the heavy-ion standard model and understand the perfect liquid from multibody QCD (precision bulk observables hand in hand with hard probes)

Vista: The next decade

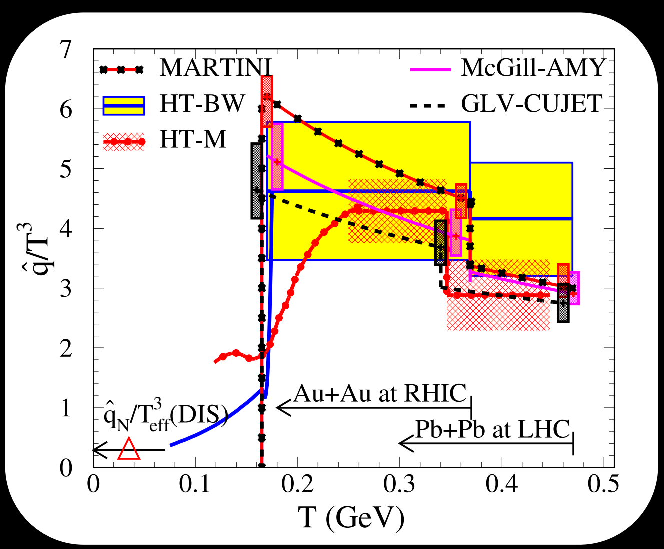
large still growing active experimental (RHIC, LHC) and theoretical community
many and highly cited papers
new detectors and new facilities



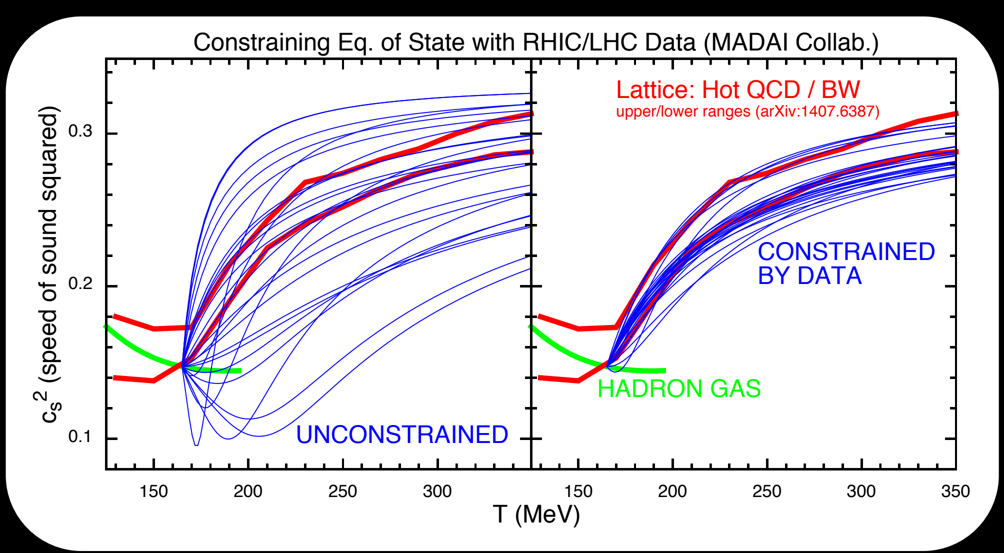
transport coefficients



bulk observables



hard probes



EoS

Analogy: Superconductivity

experimentally discovered 1911:

Heike Kamerlingh Onnes

macroscopic theory 1950:

Ginzburg-Landau

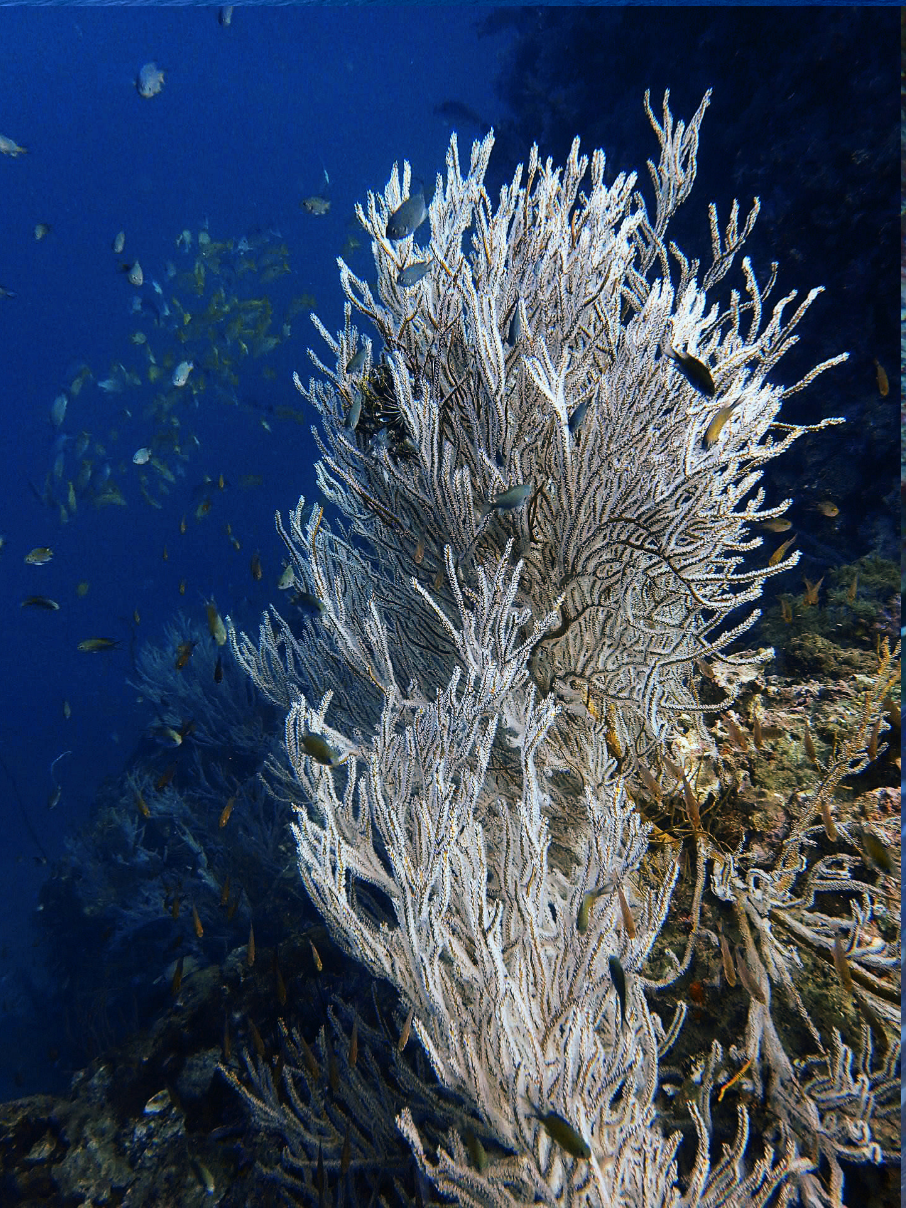
microscopic theory 1957:

Bardeen, Cooper and Schrieffer

Surprises?!

Vista

If you dive in a bit deeper you might be surprised with what you encounter and how it changes your view




Thank you for your attention!