

Probing the Early Universe with Extreme Temperature Physics

Cole Faraday

Research group (Theory): Blessed Ngwenya (PhD), Cole Faraday (MSc), Nia Ocallaghan (Hons), Frederik Burgers (Hons)

Supervised by A/Prof. W. A. Horowitz

4th of October 2023 (PG Showcase)

University of Cape Town



DEPARTMENT OF
PHYSICS
UNIVERSITY OF CAPE TOWN

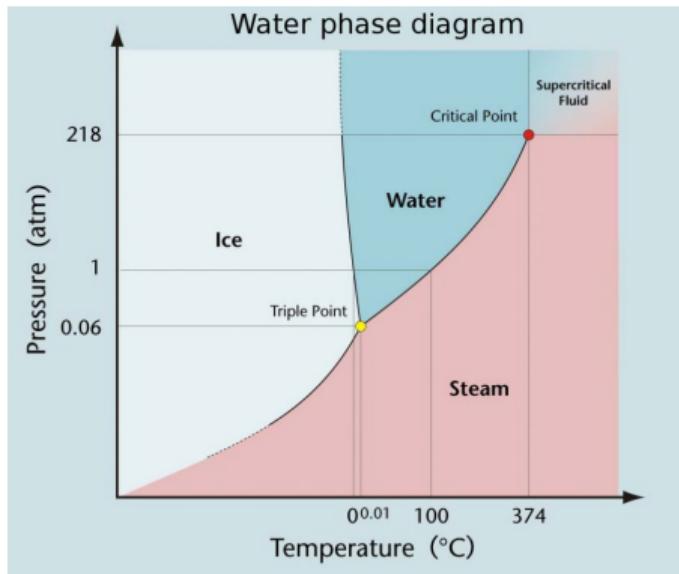


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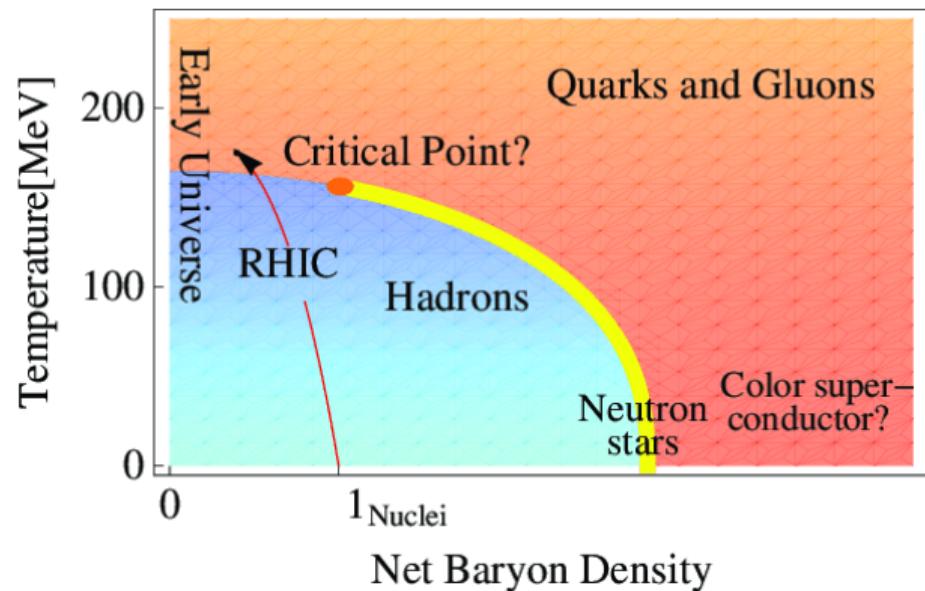
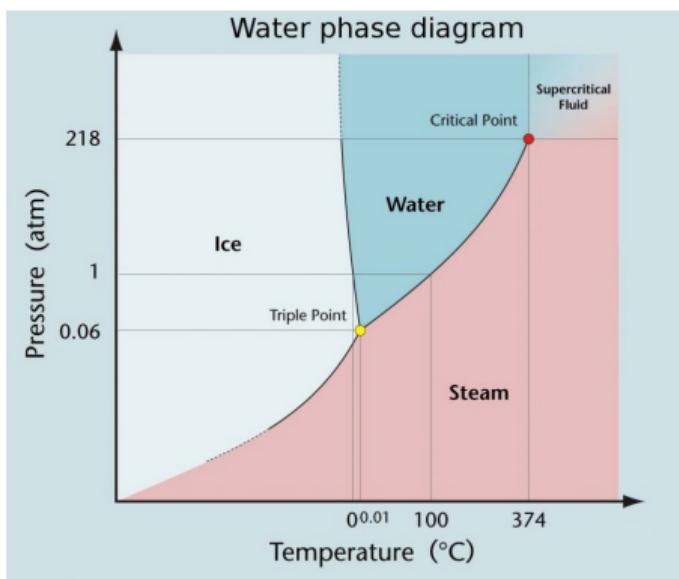
Puzzles and Unanswered Questions

- What happens as you heat up water?

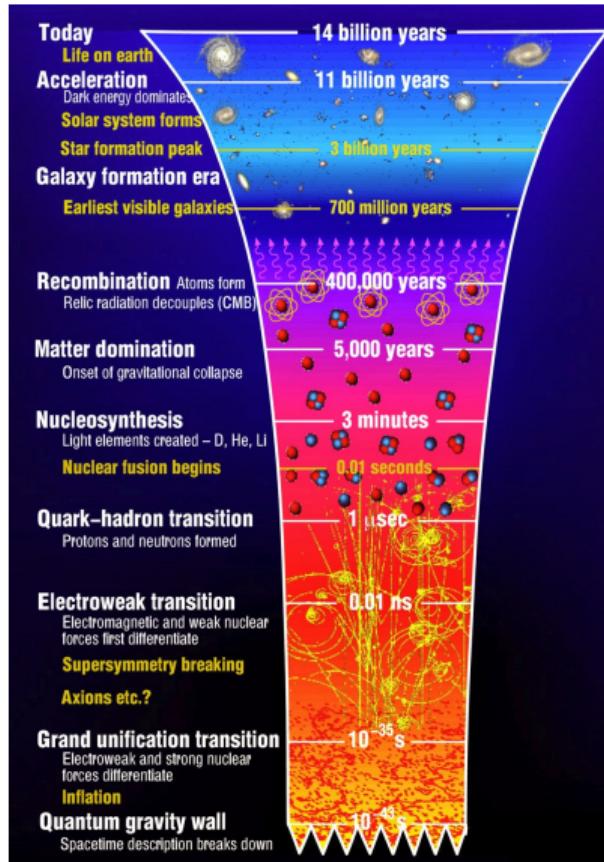


Puzzles and Unanswered Questions

- What happens as you heat up water?
- How about at temperatures *100 000× the surface of the Sun?*



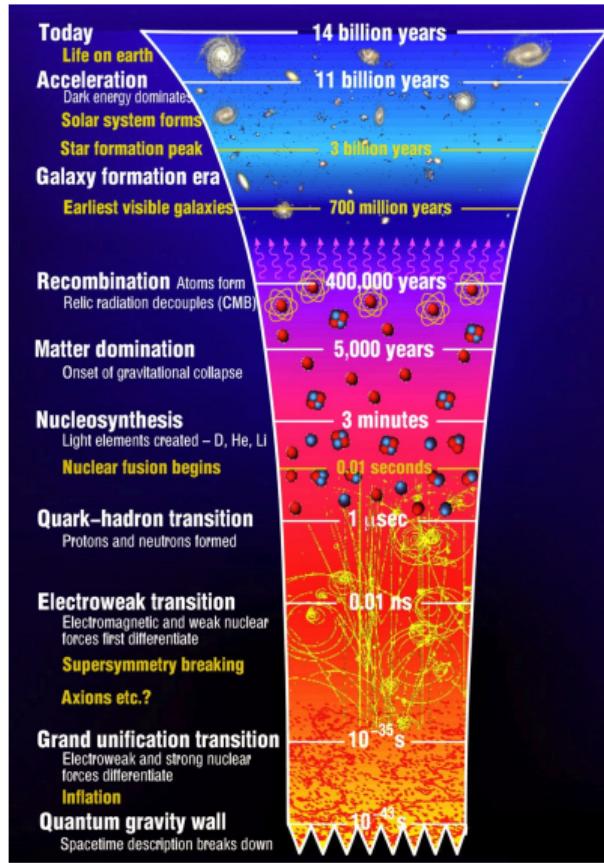
Puzzles and Unanswered Questions



Extreme matter

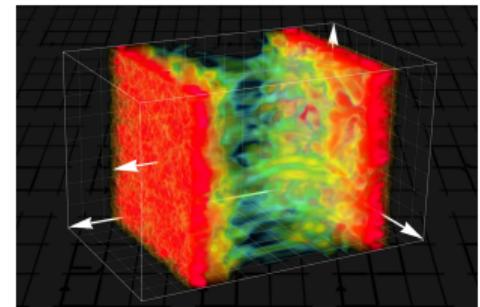
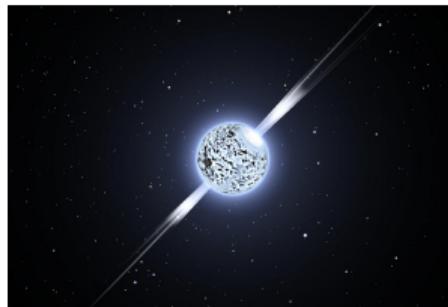
- Physics *microseconds after the Big Bang?*
 - 300 000 years before telescopic images

Puzzles and Unanswered Questions



Extreme matter

- Physics *microseconds after the Big Bang*?
 - 300 000 years before telescopic images
- Matter inside *neutron stars*?
- Dynamical origin of *spin and mass of protons*?
- Mechanism for *formation of hadrons*?



The Hottest Substance in the Universe

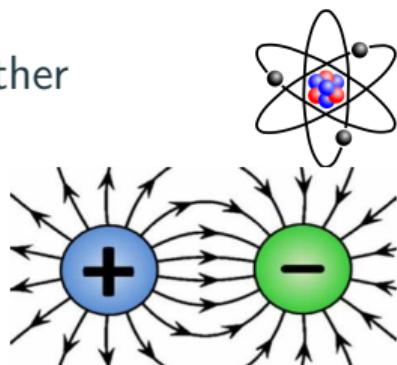
→ The *strong force* (which governs quarks, gluons, and nucleons) is crucial for answering all of these questions

Electromagnetic Force

Long range

Holds atoms together

Free charges

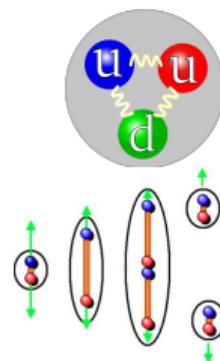


Strong Force

Short range

Holds nuclei and nucleons together

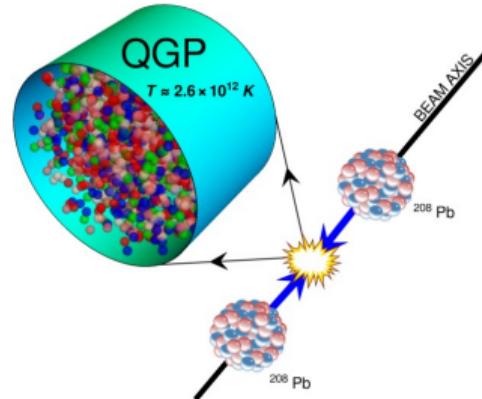
Charges *confined* to nucleons



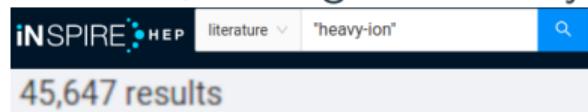
- At high temperatures (1000x the Sun) protons melt, and quarks and gluons are freed:
 - *Quark Gluon Plasma* (QGP) - created at LHC in heavy-ion collisions

Heavy-ion Physics

Quark Gluon Plasma is an ideal probe of the strong force since it contains freely interacting quarks and gluons → *heavy-ion phenomenology*



- Link between theory and experiment
- Numerical investigation, effective models, and rigorous theory all crucial
- Extremely active research field



Heavy-ion Physics at UCT

- *Equation of State in Lattice QCD* - Blessed Ngwenya (PhD)
- *Uncovering QGP Formation in Small Systems* - Cole Faraday (MSc)
- *Equation of Motion of a String in Heavy-ion Collisions with AdS/CFT* - Nia Ocallaghan & Frederik Burgers (Hons)
- *Heavy Flavor Correlations in Heavy-ion Collisions from AdS/CFT* - Aameer Bhamai and Ariel Levy (3rd year)

**Inconsistencies in, and short pathlength correction to,
 $R_{AA}(p_T)$ in A + A and p + A collisions**

Coleridge Faraday^a, Antonia Grindrod^b, and W. A. Horowitz^c

B-meson Nuclear Modification Factor and $v_2(p_T)$ in a Strongly Coupled Plasma in Pb + Pb Collisions at $\sqrt{s_{NN}} = 2.76$ TeV and $\sqrt{s_{NN}} = 5.5$ TeV

B. A. Ngwenya^{*} and W. A. Horowitz[†]



SA-CERN Excellence Bursary

<https://sa-cern.tlabs.ac.za/bursary/>

Amazing opportunities for:

- Graduate funding
- Visiting CERN (Switzerland) and conference funding



Thanks for listening!

I'm available to answer any questions at the Poster session

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