Phenomenology and high-energy nuclear physics

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Begin With A Joke...

- What is a "theory"?
  Aristotle: I THINK women have fewer teeth than men... (pure speculation)
  Aristotle's wife: I'll open my mouth. You count my teeth. Then count the teeth of every woman you can find. Men and women have the same no. of teeth. WTH, man! (data collection)
- What is an "experiment"?
  Collection of data, with the purpose of revealing something new about the observable universe.
- What is "experimental data analysis"?
  Analysing collected data, within the bounds of practicality and causality.

The Twilight Zone

- What is "phenomenology"?
  The twilight zone between theory and experiment.
- What is a "model" in physics?
  A coded, numerical/analytical representation of a hypothesis, based on collected experimental data, to explain said data and provide predictions about new data.
- A model:
  - can start from (experimentally vindicated) first principles, or
  - can be based entirely on collected data, or
  - can be a mixture of the two,
  - must explain the collected data; partially (in certain circumstances) or wholly; and
  - must contain predictions, leading to further experimental; and/or phenomenological; research.

Between Two Extremes

- What is "nuclear physics"?
  A study of sub-nuclear structure, particles, composition and interactions. Basically, an investigation into the building-blocks of the universe.
- Why use phenomenology in nuclear physics?
  - Classical mechanics: one extreme, analytically unsolvable beyond systems involving more than two, or three (in special circumstances), particles.
  - Statistical mechanics: another extreme, inapplicable to systems containing fewer than the Avogadro no. (6.023×10^{23}) of particles.
- The nuclear system: in the ground-state, or excited-state, contains 1 to $\approx$ 300 **unique** particles.
- A nuclear collision between 2 nuclei contains about 1000 **unique** particles.

Fields Of Colour

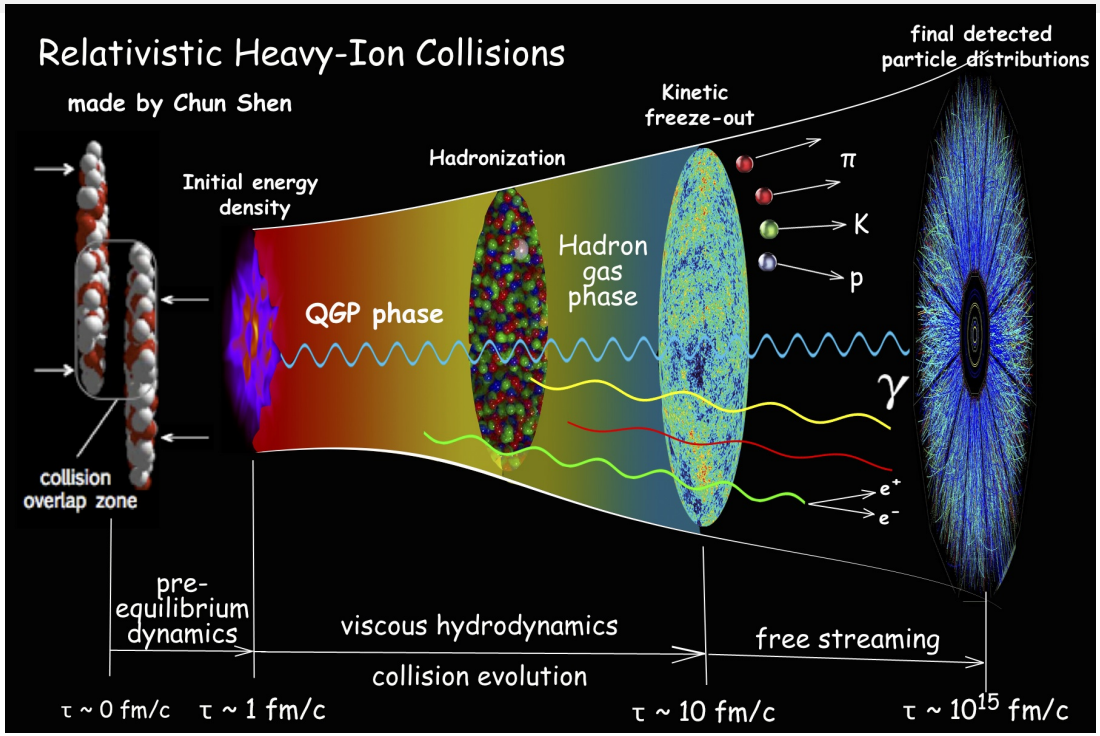
- Nuclear collisions: at moderate-to-high temperatures and high densities, nuclear matter "melts" into fields.
- Fields interact with each other according to Quantum Field Theory (QFT).
- Colour quantum numbers come into play.
- Strong interaction dominates.
- Quantum Chromodynamics (QCD) is required to explain the behaviour and the evolution of the system.
- QCD has its shortcomings.

The Science Of Deduction

Investigations are carried into:

- the composition of the collision system,
- the evolutionary stages of the system,
- the phases and phase-transitions of the system,
- the thermodynamic properties of the system,
- the microscopic interactions amongst the fields,
- signatures of QGP and
- the shape, size and distribution of the collision system.

End With A Bang!



- Relativity affects the shape of the nuclei before collision.
- Pre-equilibrium stage: particles turning into fields.
- Equilibrium stage: fields evolving with time.
- Post-equilibrium stage: fields de-coupling & new particles forming.