Theory and Phenomenology of Relativistic Heavy-Ion Collisions

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Project description

In the history of the early universe, the confinement transition was crossed when the universe was about one microsecond old, but as far as we know this did not leave any visible imprint accessible to present astronomical observations. In the early 1980's, the idea emerged to collide heavy nuclei in order to produce in the laboratory nuclear matter at high temperature and density, possibly sufficient to reach and go beyond the critical line. Subsequently, several experiments have had all or part of their scientific program devoted to the study of heavy ion collisions. The study of high-energy heavy-ion collisions is an emerging field of research being at the interface between particle physics and nuclear physics, it carries the burden that many topics which are familiar to workers in one branch may not be familiar to workers in the other branch.

Relativistic heavy-ion collisions are so far the only way to produce compressed nuclear matter in the laboratory. Super-dense baryonic matter (moderate temperature) can be realised at GSI, Darmstadt, Germany. Another interesting domain of phase space is at high temperature and low baryon density which is more appropriate to mimic early universe scenario is realised in ultra-relativistic heavy ion collisions at Super Proton Synchrotron (SPS) at CERN, Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory and Large Hadron Collider (LHC) at CERN. The latter experiments offer the opportunity to study the properties of matter at high temperature and low density.

Relativistic heavy-ion collisions are directed toward creating and studying the quark-gluon plasma (QGP), a new state of matter predicted by lattice Quantum Chromodynamics (QCD) calculations. The physics of heavy ions ranges from highly energetic quarks and gluons described by perturbative QCD to a bath of strongly interacting gluons at lower energy scales. These gluons quickly thermalize and form QGP, while the energetic partons traverse this plasma and end in a shower of particles called jets.

In this study, the interns will focus on:

i. Studying different stages of heavy ion collisions.
ii. Identifying which theories and models of physics are relevant for different stages of the collisions.
iii. Modelling of different stages of heavy ion collisions.
iv. Analyzing the final particle spectra.