Cours de formation doctorale 2019

Titre : Selected Topics on Heavy Ion Collisions

Intervenant(s) : Elena G. Ferreiro

Durée (en heures + répartition dans la semaine) : 15 h de cours (6 cours de 2.5 h en 3 jours)

Langue du cours : Français ou anglais / Supports en anglais

Résumé (incluant un plan si possible) :

In these lectures we present the key ideas driving the field of relativistic heavy ion physics and develop in a brief way some of the theoretical tools needed for the description and interpretation of heavy-ion collision experiments at their phenomelogy.

We will start by an introduction where I describe the main features of Quantum Chromodynamics (QCD), i.e. asymptotic freedom and deconfinement, followed by the motivation and definition of principal kinematics in heavy-ion collisions. The collision evolution together with its initial conditions in different scenarios will also be discussed.

The phase diagram of nuclear matter and the transition to the Quark Gluon Plasma (QGP), along with its characterisation and signatures are presented: stopping and jet quenching as a signature of creation of dense nuclear matter, collective flow as a tool of compression of nuclear matter, strangeness enhancement and hadrons abundances as a signal of chemical equilibrium and restoration of chiral symmetry, J/psi and upsilon suppression as a signature of colour screening in a dense QGP and thermal dileptons and direct photons as indication of radiation of a hot plasma.

We will conclude with a discussion on quarkonium as a tool for the characterisation of the plasma and the cold nuclear matter effects involved in its production.

Semaine prévue pour le cours :

- 22 mai : de 10h00 à 12h00
- 23, 24 mai : de 10:00 à 12:30 et de 14:00 à 17 :30

Plan du cours

Introduction: Brief history of the quark model and QCD.

- A brief history of the quark model
- Problems with the quark model
- A glimpse at the modern picture
- The QCD: Feynman rules, quarks confinement, asymptotic freedom
- Renormalisation, factorisation
- Parton Distribution Functions, Hadronization and Fragmentation Functions
- Deep Inelastic Scattering

Heavy Ions Collisions

- Definition of principal kinematics variables
- Collision evolution
- Collision geometry: Centrality and Glauber Model
- Analysis method (comparison: proton-proton, p-nucleus and nucleus-nucleus)
- Motivations for the study of heavy-ion collisions at high energy

Initial conditions

- Modification of the gluon flux
- Shadowing
- Colour Glass Condensate
- Phenomenology at high energies

Characterisation of the quark-gluon plasma

- Where can we find nuclear matter at high density and high temperature?
- Short remain of thermodynamics: definition of phases transition
- Nuclear matter phase diagram

Observables: QGP signatures

- Jet quenching
- Collective flow
- Strangeness enhancement
- Thermal dileptons & direct photons
- Quarkonium suppression

Quarkonium

- Quarkonium as a tool
- Cold Nuclear Matter effects on quarkonium
- QGP effects on quarkonium

Location : IPN Orsay Building 100 Room M905Bis