Phase diagram of Quantum Chromodynamics

CFU: 2

Teaching staff

Name Surname: Marco Ruggieri

Email: marco.ruggieri@dfa.unict.it

Office: 326

Reception hours: Monday and Tuesday, 15:00 -18:00

Program of the course:

This course provides a comprehensive overview of Quantum Chromodynamics (QCD) and gauge theories, with a focus on the behavior of strongly interacting matter under extreme conditions of temperature and density. Starting from the fundamentals of gauge theories and QCD, the course explores key phenomena such as color confinement, chiral symmetry breaking, and color deconfinement. Particular attention is given to the QCD phase diagram, including its critical endpoint, as well as the physics of superdense quark matter, superfluidity, and color superconductivity. Applications to the equation of state of dense matter and the physics of neutron stars are discussed, along with the impact of hot and dense QCD on the QCD axion.
In detail, the topics of the course are the following.

1) Introduction to gauge theories and Quantum Chromodynamics
2) Color confinement and chiral symmetry breaking: a modern overview

3) Quantum Field Theory at finite temperature and density in the real-time formalism
4) Color deconfinement at finite density, 1: critical endpoint of the QCD phase diagram (theory and phenomenology)
5) Color deconfinement at finite density, 2: superdense phases of QCD, Dyson-Schwinger equations in dense QCD, superfluidity and superconductivity of dense quark matter, quarkyonic phases
6) Applications to the equation of state of strongly interacting matter and neutron stars
7) Dense and hot-QCD effects on the QCD axion

Bibliography:

Lecture notes of the course, prepared by the teacher

Slides of the lectures

Review papers on the QCD phase diagram

Kapusta and Gale, Finite-Temperature Field Theory, Cambridge University Press, seconda edizione (2023)

Mussardo, Statistical Field Theory, OUP Oxford seconda edizione (2022)