

Scuola Superiore di Catania

Classe delle Scienze Sperimentali Corso specialistico Ambito Scienze e Tecnologie

"Cromodinamica quantistica" a.a.2015-2016

The basic idea and concepts of gauge theories. Classical QCD action. Quantizing QCD. Non abelian gauge theory: renormalization, asymptotic freedom and confinement. Perturbative and non-perturbative regime of QCD. Chiral Symmetry and chiral phase transition. Nambu-Jona-Lasinio (NJL) Model and dynamical symmetry breaking at $T=0$ and at finite T . Phenomenological aspects: R ratio and colors, deep-inelastic scattering, gluon splitting in jets. Emergence of the parton model. Parton distribution functions and their basic properties. Moments of structure functions and sum rules. Parton model in neutrino interactions. Proton-Proton collisions at TeV energy. Elementary calculation of $pp \rightarrow gg, qq, qg \rightarrow$ hadrons in the perturbative regime. Hadronization by independent fragmentation function. QCD - improved quark-parton model and Branching functions. Evolution equations: GLAP and BFKL. QCD improved quark-parton model

Lattice Gauge approach to QCD: Wilson line, Gluons and Quarks in the lattice, Wilson loop. Lattice QCD at finite temperature. Basic thermodynamics of the phase transition from hadronic matter to the quark gluon plasma. QCD phase transition at high T on Lattice: Polyakov loop and chiral susceptibility. Trace Anomaly in QCD. Strongly coupled QCD matter.

Quark-Gluon Plasma in the Early Universe: solution of the Friedmann equation. Quark-Gluon Plasma in ultra-relativistic heavy ion collisions and transport properties of QCD matter.

Suggested reading

- 1) "The Theory of Quark and Gluon Interaction", F. J. Yundurain, Springer Press, 2006
- 2) "Lattice Methods for Quantum Chromodynamics", T. De Grand and C. DeTar, World Scientific, 2006.
- 3) "Quark-Gluon Plasma", K.Yagi, T. Hatsuda and Y Miake, Cambridge University Press, Cambridge, 2005.
- 4) "An Introduction to Quark and Gluons", F. E. Close, Academic Press London, 1979.
- 5) "Handbook of Perturbative QCD", G. Sterman et al., Review of Modern Physics 67 (1995) 158.
- 6) "Resource Letter: Quantum Chromodynamics", A. S. Kronfeld and C. Quigg, American Journal of Physics 78 (2010) 1081.