

HADRONIC PHYSICS (6 ECTS)

The course will be delivered through 20 lectures of 1.5 hours each, 2 discussion sessions, and 5 in-person tutorial sessions, distributed over a two-week period. Lectures during the first week will be conducted online, whereas those in the second week will be delivered in person. The discussion sessions will be tailored to the characteristics and preferences of the student group. The tutorial sessions will be devoted to addressing questions related to the course content, discussing proposed exercises, and providing further academic support as needed.

Lectures and Teachers:

Sergi González-Solís de la Fuente

G1. Introduction to the Standard Model (I): fundamental particles and their interactions

G2. Introduction to the Standard Model (II): the quark model (mesons and baryons)

G3. Colour and Quantum ChromoDynamics (QCD)

G4. QCD Lagrangian

G5. Tutorship S. González-Solís

Volodymyr Magas

M1. Klein-Gordon and Dirac equations.

M2. Relativistic collisions and Feynman diagrams.

M3. Quantum electrodynamics of particles with spin 0, examples.

M4. Quantum electrodynamics of particles with spin 1/2, examples.

M5. Tutorship V. Magas

Assumpta Parreño

P1. Phenomenology of the NN interaction. One-meson exchange model.

P2. Non-perturbative methods: Lattice QCD and Effective Field Theories.

P3. Effective theories (I).

P4. Effective theories (II).

P5. Tutorship A. Parreño

Juan Miguel Torres-Rincón

J1. Deep inelastic scattering.

J2. Naive parton model.

J3. Parton model and QCD.

J4. Quark-gluon plasma.

J5. Tutorship J. Torres

Vincent Mathieu

V1. Lorentz transformations and kinematics

V2. Observables: decay rates and cross-sections

V3. Application I

V4. Application II

V5. Tutorship V. Mathieu

Evaluation:

Professors will design a series of short projects, each integrating different concepts and methodologies covered in the course. On the first day of online classes (12 April 2027), each student will be assigned one of these projects. Students will have the opportunity to discuss the development and progress of their assigned project with the instructors, particularly during scheduled tutorial sessions.

Continuous assessment will be based on an individual oral presentation of the assigned project, delivered online on 26 May 2027 at an agreed time. This assessment component will contribute 60% of the final course grade. Following the project presentation, students will undertake an individual oral examination conducted online and covering the full course contents. The oral examination will account for the remaining 40% of the final grade.

The evaluation will be structured as follows:

Project presentation: 10 minutes for presentation, followed by 5 minutes for questions and discussion.

Oral examination: up to a maximum duration of 15 minutes.

Basic Bibliography:

1. "Quantum Field Theory", F. Mandl y G. Shaw, Wiley and Sons Ltd, 1984.
2. "Models of the nucleon: from quarks to solitons", R.K. Bhaduri, Addison-Wesley, 1988.
3. "Quarks and Leptons: an introductory course in modern particle physics", F. Halzen and A.D. Martin, Wiley and Sons Ltd., 1984.
4. "Pions and Nuclei", T.E.O. Ericson, W. Weise. Oxford-Clarendon Press, 1988.
5. "Electroweak and Strong Interactions", F. Scheck, Springer-Verlag, 3rd edition.
6. "Theoretical Nuclear and Subnuclear Physics", J.D. Walecka. Oxford University Press, 1995.
7. "Gauge theories in Particle Physic", I.J.R. Aitchison and A.J.G. Hey
8. "Introduction to the Quark Model of Elementary Particle", D. Flamm and F. Schöberl. Gordon and Breach, Science Publishers Inc. 1982.
9. "Quantum Theory of Many Particle Systems", A.L. Fetter y J.D. Walecka, Dover, 2003.
10. "A Guide to Feynman Diagrams in the Many Body Problem", R.D. Mattuck (Dover, New York, 1992), Second Edition.
11. "The Meson theory of nuclear forces and nuclear structure", R. Machleidt, Adv. Nucl. Phys. 19 (1989) 189-376.
12. "Production, structure and decay of hypernuclei", H. Bando, T. Motoba, J. Zofka, Int.J. Mod. Phys. A5 (1990) 4021-4198.
13. "In-medium nuclear interactions of low-energy hadrons", E. Friedman, A. Gal, Phys. Rept. 452 (2007) 89-153.

14. "Chiral Effective Field Theory and Nuclear Forces", R. Machleidt and D.R. Entem, Phys. Rept. 503, 1-75 (2011); arXiv:1105.2919
15. "Lattice QCD for novices", G. Peter Lepage, Proceedings of HUGS 98, edited by J.L. Goity, World Scientific (2000); arXiv:hep-lat/0506036
16. "Introduction to Lattice QCD", Rajan Gupta, arXiv:hep-lat/9807028