UNIVERSITAT DE BARCELONA

Master on Astrophysics, Particle Physics and Cosmology

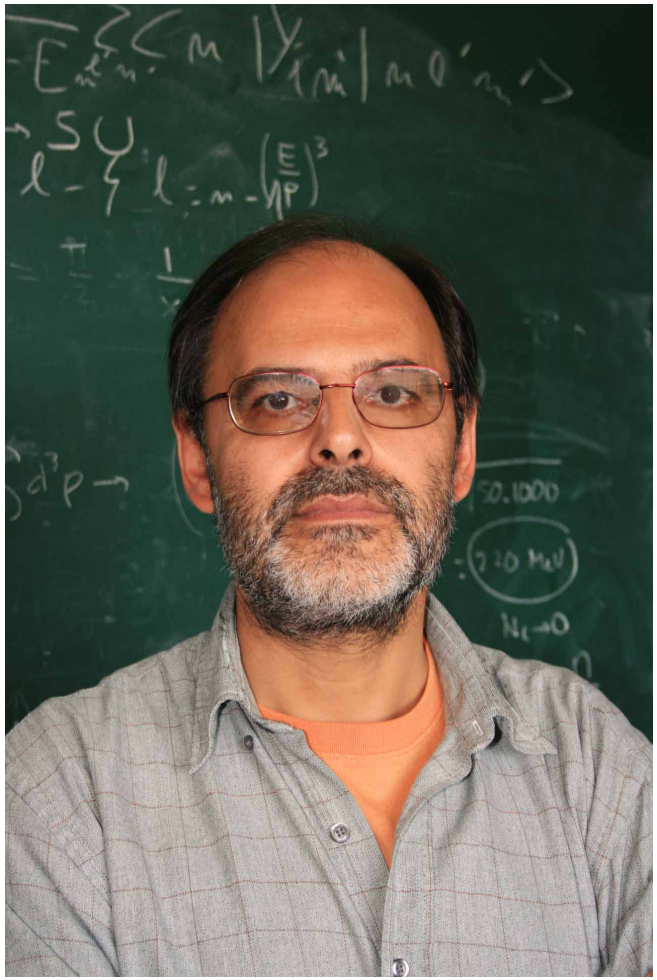
Elementary Particles

Joan Soto Lluís Garrido

Mon-Thu; 16:30-17:30; V12M

Lecturers

Joan Soto



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Lluís Garrido

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Aim

- Learning the main characteristics of elementary particles
- Learning the main features of fundamental interactions
- Calculating tree level observables in the QFTs relevant to nature
- Learning the basics of current detectors
- Learning the main features of key HEP experiments

- **Skills**
  - Critical assessment
  - Problem solving
  - Team work

Previous Knowledge

- **Needed:**
  - Quantum Mechanics
  - Special Relativity
- **It will help:**
  - Introduction to Particle and Nuclear Physics
  - Introduction to High Energy and Collider Physics

Syllabus

1. **Overview of particle physics**

   Elementary particles and interactions; Baryons and mesons; Weak interactions; More generations.

2. **Fields for Free Particles. Discrete symmetries**

   Scalar fields; Dirac Fermions; Vectors fields; C, P and T symmetries; Propagators.

3. **Continuum symmetries in Particle Physics**

   Symmetry groups and conservation laws; Rotations and angular momentum conservation; Lie groups and Lie algebras; Representations of SU(2) and SU(3).

4. **The quark model and effective theories of hadrons**

   Internal symmetries and classification of hadrons; Non-relativistic quark model; The linear sigma model; The non-linear sigma model.

5. **QED for leptons**

   Electromagnetic interaction as a U(1) (Abelian) gauge theory (QED); Calculation of scattering amplitudes and cross sections at tree level for several processes in QED ($e^-\mu^- \to e^-\mu^-$, $e^+e^- \to \mu^+\mu^-$, $e^-e^- \to e^-e^-$, $e^-\gamma \to e^-\gamma$). Mandelstam variables. Helicity conservation at high energies.

6. **QED and the structure of hadrons**

   Concept of form factors; $e^- p \to e^- p$ elastic scattering: proton form factors; $e^- p \to e^- X$ inelastic scattering; Bjorken scaling and quarks; quark distribution functions; the gluons; the QCD Lagrangian.

7. **Weak Interactions**

   Weak decays and parity violation: V-A weak charged currents; W boson as mediator of weak charged currents; Low energy tests: muon decay, nuclear beta decay, neutrino decay, neutrino-electron scattering; fermion mixing matrix; Weak neutral currents: Z^0 and the GIM mechanism; CP violation.

8. **Electroweak Unification**

   Weinberg-Salam Model of Electroweak Interactions; Spontaneous symmetry breaking: Higgs mechanism; Masses of the Gauge Bosons and of the Fermions.

9. **Experimental Techniques in Particle Physics**

   Interaction of particles with matter. Types of sub detectors: calorimeters, tracking and Cherenkov. Accelerators. Measurement of luminosity. Trigger, event reconstruction and data analysis

10. **Example of a HEP experiment: ALEPH**

    The Aleph detector. Measurement of the number of light neutrinos. Jets physics. Search for new physics.

11. **Heavy flavour experiments**

    The LHCb and BaBar experiments. e^+e^- vs pp machines. Flavor tagging. Secondary vertex reconstruction. Lifetime measurements. Rare decays. CP violation. T violation.

Bibliography

- *Quarks and leptons : an introductory course in modern particle physics*, Francis Halzen, Alan D. Martin
- *Introduction to high energy physics*, Perkins, Donald H.
- *Introduction to elementary particles*, Griffiths, David J.
- *An Introduction to quantum field theory*, Peskin, Michael E.; Schroeder, Daniel V.
- *Lie algebras in particle physics : from isospin to unified theories*, Georgi, Howard

Evaluation

- 70%, in groups of two
  - Weekly exercises
  - Problem sheet
  - Summary of a research article
- 30%, individual
  - Final Exam

Thank you