# Disciplina SFI 5833
# Mecânica Quântica Relativística

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*It would be catastrophic for the future development of physics if the terminal course in theoretical physics for most Ph.D. level students in physics were nonrelativistic quantum mechanics, the fundamentals of which had essentially been perfected by 1926.*

J.J. Sakurai

## Avaliação

Uma prova (peso 0.50) baseada em listas de exercícios e um seminário (peso 0.50).

## Bibliografia

*Relativistic Quantum Mechanics*, J.D. Bjorken e S.D. Drell (**BD**)

*Advanced Quantum Mechanics*, J.J. Sakurai (**S**)

*Introduction to High Energy Physics*, D.H. Perkins (**P**)

*The Quantum Theory of Fields*, S. Weinberg (**W**)

*Introduction to Elementary Particles*, D. Griffiths (**G**)

## Programa

– **PRIMEIRA PARTE: equação de Dirac**

- **14–18 de Março**: Formulation of a relativistic quantum theory; Early attempts; The Dirac equation; Nonrelativistic correspondence (**BD 1.1, 1.2, 1.3, 1.4; 12 pp**).
- **28 de Março–1 de Abril**: Covariant form of the Dirac equation; Proof of covariance; Space reflection; Bilinear covariants (**BD 2.1, 2.2, 2.3, 2.4; 11 pp**).
- **4–8 de Abril**: Plane-wave solutions; Projection operators for energy and spin; Physical interpretation of free-particle: solutions and packets (**BD 3.1, 3.2, 3.3; 15 pp**).
- **11-15 de Abril**: The Foldy-Wouthuysen transformation: introduction; Free-particle transformation; The general transformation; The hydrogen atom (**BD 4.1, 4.2, 4.3, 4.4; 15 pp**).
- **18–20 de Abril**: The problem of negative-energy solutions; Charge conjugation; Vacuum polarization; Time reversal and other symmetries (**BD 5.1, 5.2, 5.3, 5.4; 11 pp**).

– **SEGUNDA PARTE: propagadores e espalhamento**

- **25–29 de Abril**: Propagator theory: introduction; The nonrelativistic propagator; Formal definitions and properties of Green's functions; The propagator in positron theory (**BD 6.1, 6.2, 6.3, 6.4; 21 pp**).
- **2–6 de Maio**: S-matrix expansion in the interaction representation; Dispersion relations and causality (**S 4-2, 2-7; 13 pp**). Wave-optical discussion of hadron scattering; The Breit-Wigner resonance formula (**P 4.7, 4.8; 7 pp**).

- **9–13 de Maio**: Rates and cross-sections (**W 3.4; 8 pp**). Cross-sections and decay rates; Dalitz plots; Transition rates in perturbation theory (**P 4.1, 4.6, app. E; 10 pp**). Møller scattering and the photon propagator; one-meson exchange interactions (Effective potential; the Breit interaction) (**parte de S 4-6; 3 pp**).

- **16–20 de Maio**: The Feynman rules for a toy theory; Lifetime of the A; Scattering; Higher-order diagrams (**G 6.3, 6.4, 6.5, 6.6; 10 pp**). **Primeira prova**.

– **TERCEIRA PARTE: aplicações e renormalização**

- **Escolha dos artigos para o seminário final**.

- **23–25 de Maio**: Coulomb scattering of electrons; Some trace theorems; the spin-averaged Coulomb cross-section; Coulomb scattering of positrons; Electron scattering from a Dirac proton; Higher-order corrections to electron-proton scattering (**BD 7.1, 7.2, 7.3, 7.4, 7.5; 21 pp**).

- **30 de Maio–3 de Junho**: Bremsstrahlung; Compton scattering; Pair annihilation into gamma rays; Electron-electron and electron-positron scattering; Polarization in electron scattering (**BD 7.6, 7.7, 7.8, 7.9, 7.10; 26 pp**).

- **6–10 de Junho**: Electron-positron scattering in fourth order; Vacuum polarization; Renormalization of external photon lines (**BD 8.1, 8.2, 8.3; 14 pp**).

- **13–17 de Junho**: Self-mass of the electron; Renormalization of the electron propagator; The vertex correction; The Lamb shift (**BD 8.4, 8.5, 8.6, 8.7; 19 pp**).

- **20–24 de Junho**: Electron-quark interactions; Hadron production in $e^+ e^-$ scattering; Elastic electron-proton scattering; Inelastic electron-proton scattering; The parton model and Bjorken scaling; Quark distribution functions (**G 8.1, 8.2, 8.3, 8.4, 8.5, 8.6; 20 pp**).
- **27–30 de Junho**: Seminarios. Possíveis artigos:
  - *Relativistic cut-off for quantum electrodynamics*, R. P. Feynman Phys. Rev. **74** (1948) 1430–1438.
  - *The radiation theory of Tomonaga, Schwinger, and Feynman*, F. J. Dyson Phys. Rev. **75** (1949) 486–502.
  - *The theory of positrons*, R. P. Feynman Phys. Rev. **76** (1949) 749–759.
  - *Space-time approach to quantum electrodynamics*, R. P. Feynman Phys. Rev. **76** (1949) 769–789.