Flavour Physics

1. Symmetries (4/11/03): 11.00-13.00
   - A bit of Philosophy
   - Discrete Symmetries: C, P, T, CP and CPT
2. The Standard Model
   (a) Gauge Theories (4-6-11/11/03): 11.00-13.00
   (4 hours)
   - Abelian and non-Abelian gauge groups
   - Gauge group of the SM: $SU(3) \times SU(2) \times U(1)$
   - Spontaneous Symmetry Breaking:
     global and local $U(1)$; the Higgs mechanism
   - SSB of $SU(2) \times U(1)$ and gauge boson masses

   (b) Vector Fermions (11-13/11/03): 11.00-13.00
   (3 hours)
   - $\mathcal{L}_{QED}$ and $\mathcal{L}_{QCD}$
   - One-loop calculations in QED and QCD:
     examples

   (c) Chiral Symmetry
   (18-20-25-27/11/03, 02/12/03): 11.00-13.00
   (10 hours)
   - Weyl, Majorana and Dirac fermions
   - The global symmetries of QCD
   - Linear and non-linear σ model
   - Quark masses and pseudoGoldstone bosons
   - The $U_A(1)$ problem
   - The ABJ anomaly in different regularizations

- The QCD vacuum and the strong CP problem
- Scale invariance and low-energy SYM

(d) The Standard Model (4-9/12/03)

(4 hours)

- The $SU(2) \times U(1)$ lagrangian
- Yukawa couplings and fermion masses
- Gauge anomalies cancellation; breaking of B, L and $B - L$ conservation
- The hierarchy problem

3. The Flavour Problem (9-12-14-16-19-21-23-26/01/04): 11.00-12.00

(a) The Family and Flavour puzzles:

(1 hour)

- A bit of Philosophy

(b) Fermion masses

(2 hours)

- The Yukawa's hierarchy
- The see-saw mechanism
- Charge quantization
- Textures

(c) Quark and Lepton Mixings

(4 hours)

- The Cabibbo angle
- The GIM mechanism and the charm
- CP violation and the CKM mixing matrix
- CKM parametrizations

- The Jarlskog determinant and the Unitarity Triangle
- Lepton mixing: the PMNS mixing matrix
- Majorana neutrinos and additional phases

(d) Comparison of the CKM and PMNS matrices
(1 hour)

4. Introduction to Theoretical Approaches
(27-29/01/04, 3/02/04): 11.00-13.00
(6 hours)

- The OPE expansion: $\mathcal{L}_{\Delta S=1}$ and $\mathcal{L}_{\Delta S=2}$; the Wilson coefficients, boxes and penguins
- HQET and its symmetries
- Lattice computations
- The $1/N$ expansion
- Extraction of $|V_{ij}|$ using these methods

5. CP violation

(a) B physics (5-10-12/02/04): 11.00-13.00
(5 hours)

- The $B-\bar{B}$ mixing and the B_B-parameters
- $b \to s\gamma$ and $b \to sg^\star$
- Babar and other facilities
- $\sin 2\beta$ and $\sin(2\beta+\gamma)$
- The SM and beyond

(b) K physics (12-17/02/04)
(3 hours)

- Difference with the B-meson system

- The $K - \bar{K}$ mixing and the B_K-parameters
- ϵ and ϵ'/ϵ
- The $\Delta I = 1/2$ problem
- Rare decays and bounds on new physics

(c) Constraining the Unitarity Triangle
(19/02/04):11.00-13.00
(2 hour)

(d) The Electric Dipole Moment
(15-17/03/04): 11.00-12.00
(2 hours)

- The experiment for neutron EDM
- The strong CP problem revisited
- $SU(2) \times U(1)$ and bounds on new physics
- The lepton EDM

6. ν Physics
(12 hours)

(a) Masses (24-26/02/04):11.00-13.00

- The tritium decay and the m_ν mass scale
- The $0\nu\beta\beta$ decay and the Majorana character

(b) Oscillations (2-4-9-11/03/04)

- Theory of the oscillations
- Oscillation in matter
- Atmospheric Neutrinos; SK and K2K
- Solar Neutrinos; SNO
- Reactors; KamLand;
LSND and sterile neutrinos

- Future experiments and CP violation:
  beams, superbeams and the Neutrino Factory

7. The matter-antimatter asymmetry

   (19-22-24-26-29-31/03/04, 2-5/04/04): 11.00-12.00

   (8 hours)

   - The problem and the Sakharov conditions
   - Baryogenesis à la GUT
   - EW Baryogenesis
   - The Affleck-Dine mechanism
   - Leptogenesis

8. Other items: miscellanea 7-9-11/04/04: 11.00-12.00

9. What do we know on the FP from:

   (3 hours)

   (a) the MSSM
   (b) the GUT
   (c) the Extra Dimensions
   (d) the Strings