# ICTP DIPLOMA PROGRAMME IN HIGH ENERGY, COSMOLOGY AND ASTROPARTICLE PHYSICS 2018-19

## SYLLABUS

## **Introduction to Particle Physics** - {24 Lectures = 36 hours} A. Smirnov

**I. Introduction**

Elementary and composite particles
Units and scales

**II. Discoveries of particles. Main notions and concepts**

1. Early discoveries

Electron, proton, neutron, photon.
Neutrino. Fermi theory of the weak interactions.

2. Detection of particles

Principles of detection of particles.
Radiation. Ionization.
Scintillations. Cherenkov radiation

3. Cosmic rays and discoveries of particles

Cosmic rays.
Positron.
Muon.
Pion. Pion decay
Strange particles. Kaons. Strangeness. Flavor

4. Acceleration of particles

Linear accelerators.
Cyclic accelerators.
LEP, Tevatron, LHC
First accelerator experiments. Muon neutrino.
.

5. Quarks

Classification of hadrons.
Isospin. Hypercharge.
SU(3)-symmetry. Eightfold way.
u, d and s quarks.
Introduction of color.
Quark jets.
Electron - positron annihilation to hadrons.
Cabibbo mixing.

6. Deep inelastic scattering

Scaling. Partons.
Violation of scaling.

7. Resonances.

Evolution matrix and S-matrix.
Optical theorem.
Total decay rate and total cross-section.
Resonances.
Observations of resonances.

8. Heavy leptons and quarks

Charmed particles. GIM mechanism. Discovery of J/ psi.
tau-lepton.
CKM-mixing.
Bottom quark. B-physics.
Top quark.
Tau neutrino.

9. Discoveries of the gauge bosons and Higgs boson

Intermediate bosons W, Z.
Gluons.
Higgs boson.

**III. Symmetries and Interactions**

1. Symmetries at classical and quantum level

Symmetries and transformations.
Conservation laws.
Properties of matrix elements.

2. Parity

P-transformations.
Parity conservation.
Parity of pion and other particles.
Parity violation.

3. Charge conjugation.

C-transformation.
C-parity.
Violation of C-symmetry.

4. CP-violation.

CP- properties of neutral K mesons.
Discovery of CP - violation.
Direct CP - violation.
CP - violation in B-meson system.

5. U(1) - symmetries

Baryon number.
Lepton number. Neutrinoless double beta decay
B-L quantum number
Individual leptonic numbers.

5. Neutrino oscillations and flavour conversion

Neutrino oscillations.
MSW – effect.
Solar neutrino conversion.
Oscillation experiments

6. SU(2)-symmetry.

Isospin symmetry.
Isospin and electric charge.
G-parity.

**References**

C. Quigg, ``Gauge theories of the strong, weak and electromagnetic Interaction".

D. Perkins, ``Introduction to High Energy Physics", Addison-Wesley, 2000.

B. R. Martin and G. Shaw, ``Particle physics", Wiley 1997.

G. Kane, ``Modern elementary particle physics", Addison Wesley, 1993.

D. Griffiths, ``Introduction to particle physics"

A. Bettini, ``Introduction to particle physics",

I. S. Hughes, ``Elementary particle physics", Cambridge Univpress.

M. Fukugita and T. Yanagida , ``Physics of Neutrinos", Springer-Verlag,
Berlin Heidelberg 2003

Yuval Ne'eman, ``The particle hunter" Cambridge press,

Jeff C. Bryan, Introduction to Nuclear Science, CRC Press,
Taylor & Francis Group, 2008.