

Standard Model and Beyond

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Topics:

1. Preliminaries

Lorentz invariance; scalars, vectors, fermions; Natural units
Symmetries, Lagrangian formulation
U(1) gauge theory, QED, Feynman diagrams
Cross-section and decay rate

2. The standard model

$SU(3)_c \otimes SU(2)_L \otimes U(1)_Y$ gauge theory
Quarks and Leptons
Spontaneous symmetry breaking (Higgs mechanism) and W, Z masses
QCD, QED, Weak interactions

3. Collider processes

Collider kinematics; invariant mass, transverse mass
 $e^-p \rightarrow e^-X$ (DIS), ν - N scattering
 $e^+e^- \rightarrow \mu^+\mu^-$, Z -boson, W -boson
Parton distribution function, $pp \rightarrow \ell^+\ell^-$, $pp \rightarrow t\bar{t}$, $pp \rightarrow h$

4. Precision processes

Quark masses and mixing, neutrino masses and oscillation
Loop processes, renormalization and running couplings
Flavor changing neutral currents (FCNC), $\Delta F = 1, 2$ processes, CP violation
Precision electroweak observables

5. Beyond the standard model - I

Hierarchy problem and the case for new physics
Supersymmetry, composite Higgs, extradimensions (AdS), little Higgs, ...
Searches for new physics and constraints on new physics

6. Beyond the standard model - II

Particle dark matter
Neutrino mass models
Baryogenesis

Reference books:

1. F. Halzen and A. D. Martin, “Quarks And Leptons: An Introductory Course In Modern Particle Physics,” New York, USA: Wiley (1984) 396p.
2. M. E. Peskin and D. V. Schroeder, “An Introduction to quantum field theory,” Reading, USA: Addison-Wesley (1995) 842 p.
3. D. H. Perkins, “Introduction to high energy physics,” Reading, USA: Addison-Wesley (1972) 353 p.
4. D. Griffiths, “Introduction to elementary particles,” Weinheim, Germany: Wiley-VCH (2008) 454 p.

Reference articles:

1. P. Langacker, “Introduction to the Standard Model and Electroweak Physics,” doi:10.1142/9789812838360_0001 arXiv:0901.0241 [hep-ph].
2. T. Han, “Collider phenomenology: Basic knowledge and techniques,” hep-ph/0508097.
3. Y. Grossman, “Introduction to flavor physics,” doi:10.5170/CERN-2010-002.111, 10.5170/CERN-2014-003.73 arXiv:1006.3534 [hep-ph].
4. R. K. Kaul, “Naturalness and Electro-weak Symmetry Breaking,” arXiv:0803.0381 [hep-ph].