

Chapter 12

Reference Tables and Summary

This final chapter brings together the key concepts introduced throughout the book. It serves as a quick-reference guide to the Standard Model, its particles, quantum numbers, symmetries, and conservation laws.

12.1 Standard Model Gauge Group

$$SU(3)_C \times SU(2)_L \times U(1)_Y$$

$SU(3)_C$: Strong interaction (color)

$SU(2)_L$: Weak interaction

$U(1)_Y$: Weak hypercharge

12.2 Fundamental Particles

Category	Members
Quarks	Up, Down, Charm, Strange, Top, Bottom
Leptons	Electron, Muon, Tau, and three neutrinos
Gauge Bosons	Photon, 8 Gluons, W^+ , W^- , Z^0
Scalar Boson	Higgs Boson

12.3 Principal Quantum Numbers

Quantum Number	Symbol
Electric Charge	Q
Spin	s
Weak Isospin	T
Third Component	T^3
Hypercharge	Y
Color Charge	Red, Green, Blue
Baryon Number	B
Lepton Number	L
Parity	P
Charge Conjugation	C
Time Reversal	T

12.4 Major Symmetry Groups

- Translation symmetry
- Rotational symmetry
- Lorentz symmetry
- Poincaré symmetry
- $U(1)$, $SU(2)$, $SU(3)$ gauge symmetries
- Electroweak symmetry
- Chiral symmetry
- CP, CPT, and discrete symmetries
- Supersymmetry (proposed)
- Grand Unified symmetries ($SU(5)$, $SO(10)$, E_6)

12.5 Important Relations

Electric Charge: $Q = T_3 + Y/2$

Standard Model: $SU(3)_C \times SU(2)_L \times U(1)_Y$

Noether's Theorem: Every continuous symmetry corresponds to a conserved quantity.

12.6 Looking Beyond the Standard Model

Open questions include the origin of particle masses, dark matter, dark energy, neutrino masses, the matter–antimatter asymmetry, quantum gravity, and the ultimate unification of all forces.

Final Summary

The Standard Model is a triumph of modern science, describing the known elementary particles and their interactions with extraordinary accuracy. At its heart lies symmetry. Gauge symmetries, spacetime symmetries, and conservation laws provide a coherent mathematical framework from which the properties of matter and forces naturally emerge. Although many questions remain unanswered, the search for deeper symmetries continues to guide the development of theoretical physics.