

GLOSSARY

- **α -particle:** The nucleus of ${}^4_2\text{He}$ - a tightly bound state of two protons and two neutrons.
- **Impact Parameter** of a projectile scattering off a target is the perpendicular distance of the initial velocity of the projectile from the target.
- **Flux:** The number of incident particles per second per unit area.
- **Differential Cross-Section** with respect to solid angle is the number of particles scattered per unit solid angle at a given scattering angle, per unit incident flux. Differential cross-sections can also be defined with respect to other variables such as scattering angle or momentum transferred.
- **Barn (b):** Unit of scattering cross-section equal to 10^{-28} m^2
- **fermi (fm):** Unit of length equal to 10^{-15} m .
- **Electric Form Factor:**, $F(\theta)$, is the factor by which a scattering amplitude is multiplied in order to account for the finite size of the charge distribution of the target. The differential cross-section is multiplied by $|F(\theta)|^2$.
- **Electric Quadrupole Moment:**, Q , for a non spherically-symmetric charge distribution $\rho(\mathbf{r})$ is given by

$$Q = \int (3z^2 - r^2)\rho(\mathbf{r})d^3\mathbf{r},$$

where the z -axis is the axis of symmetry of the charge distribution.

- **Nucleon:** A proton or neutron.
- **Atomic Number:**, Z , is the number of protons in a nucleus.
- **Atomic Mass number:**, A , is the total number of nucleons in a nucleus
- **Nuclide:** A nucleus with a given atomic number and a given atomic mass number.
- **Isotope:** Nuclei with the same atomic number but different atomic mass number.
- **Isotone:** Nuclei with the same number of neutrons but different numbers of protons.
- **Isobar:** Nuclei with the same atomic mass number but different numbers of protons (neutrons).

- **Mirror Nuclei:** A pair of nuclides in which the number of protons in one nuclide is equal to the number of neutrons in the other and *vice versa*.
- **Mass Defect:** The difference between the total mass of the nucleons in a nucleus and the mass of the nucleus itself (equal to minus the binding energy divided by c^2).
- **Semi-empirical Mass formula:** A formula for calculating the binding energy (and hence the mass) of a nucleus from the Liquid drop Model.
- **Magic Numbers:** Nuclides with a magic number of protons or neutrons are particularly stable and tightly bound.
- **Nuclear Magnetron:** The magnetic moment of a proton with one unit of angular momentum, defined by

$$\mu_N = \frac{e}{2m_p}$$

- **Isomer:** A metastable excited state of a nucleus.
- **Islands of Isomers:** Regions of the Periodic Table where isomers are quite common.
- **Bequerel (Bq):** Unit of radioactivity corresponding to one decay per second.
- **Curie:** The number of decays per second of one gram of $^{226}_{88}\text{Ra}$. It is equal to 3.7×10^{10} Bq.
- **Alpha decay:** Radioactivity involving the emission of an α -particle.
- **Beta decay:** Radioactivity involving the emission of an electron (positron) and an antineutrino (neutrino).
- **Gamma decay:** Radioactivity in which a nucleus in an excited state decays to a lower state emitting a high frequency photon.
- **Decay constant (rate):** Probability that a radioactive nucleus will decay in unit time.
- **Mean Lifetime:** Time taken for a radioactive nuclide to decay to a quantity equal to $1/e$ times its original quantity.
- **Half-life:** Time taken for a radioactive nuclide to decay to a quantity equal to one half of its original quantity.
- **Secular Equilibrium:** The situation in a radioactive decay chain, with a long lived first parent, in which the number of daughter nuclei remains unchanged - they are being produced as fast as they decay.
- **Q-value:** The total energy released in a nuclear decay.

- **Lepton:** A particle which does not participate in the strong (nuclear) interaction. A lepton may have electric charge.
- **Helicity:** λ The sign of the component of the spin, \mathbf{s} of a particle in the direction of its momentum \mathbf{p} .

$$\lambda = \frac{\mathbf{s} \cdot \mathbf{p}}{|\mathbf{s} \cdot \mathbf{p}|}$$

- **Weak Interactions:** Interactions between particles responsible for β -decay
- **Multipolarity:** The angular momentum quantum number, L , carried away by a photon in a nuclear transition ($L=1$ is called “dipole transition”, $L=2$ is called “quadrupole transition”).
- **Fission:** The splitting of a heavy nucleus into two lighter nuclei.
- **Chain Reaction:** A reaction in which is induced by the absorption of the products of a previous reaction and whose products are then in turn absorbed to give rise to the next ‘link’ in the chain, etc.
- **Critical mass:** The minimum mass of a sample of fissile material required for a chain reaction to be sustained.
- **Fusion:** The combining of two light nuclei to form a heavier nucleus whose binding energy is greater than the combined binding energies of the initial nuclei, thereby releasing energy.
- **Isospin:** A quantum number, I , assigned to a multiplet of $(2I+1)$ particles which are almost identical except for their electric charge, which differs by one unit between members of the multiplet. The electric charge is linearly related to the third component of the isospin, which varies in integer steps from $-I$ to I .
- **Elastic Scattering:** A scattering event between two initial particles in which the final state consists only of the two initial particles.
- **Inelastic Scattering:** A scattering event between two initial particles in which the final state contains particles which are different from the two initial particles (it may or may not also contain the initial particles).
- **Accelerators:** Machines that accelerated particles (usually protons or electrons or their antiparticles) up to very high energies.
- **Cyclotron:** An accelerator in which particles move in circles under the influence of a magnetic field and accelerated by an oscillating electric field.
- **Synchrocyclotron:** A cyclotron in which the frequency of the alternating electric field is varied in order to account for relativistic effects.
- **Synchrotron:** A cyclotron in which the applied magnetic field is varied in order to account for relativistic effects.

- **Luminosity:** No. of particle collisions per unit area (usually quoted in cm^2 per second).
- **Gauge boson:** Particle that acts as a carrier for a particular interaction.
- **Propagator:** The quantum amplitude
- **Off mass-shell:** Particle whose energy and momentum do not obey the relativistic energy-momentum relation. for the propagation of a particle with a given energy and momentum.
- **Virtual Particles:** Particles that exist only for a short time and therefore can be off mass-shell
- **Feynman Diagram (graph):** A diagrammatic representation of particle scattering or decay from which the amplitude for the scattering or decay process can be deduced.
- **Feynman Rules:** A set of rules indicating how to deduce the amplitude for a scattering or decay process from a Feynman diagram
- **Yukawa potential:** A potential, which arises when a massive particle mediates an interaction, which contains an exponentially decreasing factor as well as a $1/r$ fall-off.
- **Leptons:** Particles which do not partake in strong interactions.
- **Hadrons:** Strongly interacting particles.
- **Mesons:** Hadrons with integer spin (bosons).
- **Baryons:** Hadrons with half-odd-integer spin (fermions).
- **Family:** A set of elementary particles consisting of a charged lepton and a neutrino and a quark with electric charge $+\frac{2}{3}$ and a quark with electric charge $-\frac{1}{3}$ (each quark having three possible colours).
- **Generation:** Synonymous with family.
- **Quark:** Elementary strongly interacting particle with spin $\frac{1}{2}$ and electric charge either $\frac{2}{3}$ or $-\frac{1}{3}$, from which all hadrons are made.
- **Flavour:** Type of quark (u,d,s,c,t,b)
- **Resonance:** Peak in cross section at a given centre-of-mass energy of the incident particles or of some of the final state particles, due to the formation of an unstable particle.
- **Resonance Width:** Range of centre-of-mass energy for which the cross-section exceeds one half of its peak value.
- **Decay Channel:** A set of particles into which an unstable particle may decay.

- **Branching Ratio:** the fraction of decays of an unstable particle into a particular decay channel.
- **Partial Width:** The width of a particle resonance in which the particle always decays into a particular channel.
- **Flavour:** One of six species of quarks - u,d,c,s,t,b.
- **Strangeness:** The number of \bar{s} antiquarks in a particle minus the number of s-quarks.
- **Eightfold Way:** A method of classifying hadrons, by plotting hadrons with the same spin on a plot of strangeness against I_3 .
- **Pentaquark:** A particle consisting of four quarks and an anti-quark, whose flavour is different from that of any of the four quarks.
- **Colour:** A property of a quark which can come in three varieties - R,G and B.
- **Quark Confinement:** Mechanism (due to the strong interactions) in which it is not possible to isolate a free quark (or a free gluon) in the laboratory.
- **Cabibbo angle:** Angle who tangent gives the ratio of the couplings of W^\pm to strangeness changing and strangeness conserving weak processes.
- **Cabibbo matrix:** A matrix representation of the coupling of W^\pm to the first two families of quarks.
- **CKM matrix:** A matrix representation of the coupling of W^\pm to the three families of quarks.
- **Electroweak interactions** Weak and electromagnetic interactions.
- **Weak Mixing angle:** The inverse sine of the ratio of the electron charge e and the weak coupling g_W . In the Standard Model this is also the inverse cosine of the ratio of the W -mass to the Z -mass.
- **Higgs Field:** A field which has a non-zero constant value everywhere.
- **Vacuum Expectation Value:** The value of a field everywhere in space.
- **Higgs particle:** A particle which must exist if the Higgs field exists, owing to quantum fluctuations of the Higgs field.
- **Fragmentation:** Process by which final state quarks and gluons are converted into hadrons.
- **Quantum Chromodynamics (QCD):** Theory of strong interactions in which gluons interact with quarks changing their colour.
- **Running coupling:** The effective coupling at different energy/momentum scales.

- **β -function:** The derivative of the running coupling with respect to the logarithm of the square of the energy/momentum scale.
- **Asymptotic freedom:** The decrease in running coupling with increasing energy/momentum for theories in which the β -function is negative.
- **Charmonium:** Bound states of a c -quark and a \bar{c} antiquark.
- **Valence Quarks:** The main quarks which are always inside a hadron and determine the hadron's properties.
- **Sea Quarks:** Clouds of quark-antiquark pairs that also exist within a hadron in addition to the valence quarks.
- **Parton:** A quark, antiquark or gluon.
- **Parton Distribution Function:**, $F_h^i(x)$. The probability of finding a particular parton, i , inside a fast moving hadron, h , carrying a fraction x of the momentum of that hadron.
- **Factorization:** Process by which it is possible to calculate the cross-section for hadron-hadron scattering by folding the parton distribution functions with the cross-sections calculated in perturbative QCD for the scattering of two partons extracted from the incident hadrons.
- **Intrinsic parity:** The sign of the wavefunction of a particle under the parity operation (space reversal)
- **Charge Conjugation:** The operations of exchanging particles and anti-particles.
- **CP:** The combined operation of parity and charge conjugation.