

# GLOSSARY

- **Accelerators:** Machines that accelerated particles (usually protons or electrons or their antiparticles) up to very high energies.
- **Alpha decay:** Radioactivity involving the emission of an  $\alpha$ -particle.
- **$\alpha$ -particle:** The nucleus of  ${}^4_2\text{He}$  - a tightly bound state of two protons and two neutrons.
- **Asymptotic freedom:** The decrease in running coupling with increasing energy/momentum for theories in which the  $\beta$ -function is negative.
- **Atomic Number:,  $Z$ ,** is the number of protons in a nucleus.
- **Atomic Mass number:,  $A$ ,** is the total number of nucleons in a nucleus
- **Barn (b):** Unit of scattering cross-section equal to  $10^{-28} \text{ m}^2$
- **Baryons:** Hadrons with half-odd-integer spin (fermions).
- **Bequerel (Bq):** Unit of radioactivity corresponding to one decay per second.
- **Beta decay:** Radioactivity involving the emission of an electron (positron) and an antineutrino (neutrino).
- **$\beta$ -function:** The derivative of the running coupling with respect to the logarithm of the square of the energy/momentum scale.
- **Branching Ratio:** the fraction of decays of an unstable particle into a particular decay channel.
- **Cabibbo angle:** Angle whose 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.
- **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.
- **Charge Conjugation:** The operations of exchanging particles and anti-particles.

- **Charmonium:** Bound states of a  $c$ -quark and a  $\bar{c}$  antiquark.
- **CKM matrix:** A matrix representation of the coupling of  $W^\pm$  to the three families of quarks.
- **Colour:** A property of a quark which can come in three varieties - R,G and B.
- **CP:** The combined operation of parity and charge conjugation.
- **Critical mass:** The minimum mass of a sample of fissile material required for a chain reaction to be sustained.
- **Curie:** The number of decays per second of one gram of  $^{226}_{88}\text{Ra}$ . It is equal to  $3.7 \times 10^{10}$  Bq.
- **Cyclotron:** An accelerator in which particles move in circles under the influence of a magnetic field and accelerated by an oscillating electric field.
- **Decay channel:** A set of particles into which an unstable particle may decay.
- **Decay constant (rate):** Probability that a radioactive nucleus will decay in unit time.
- **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.
- **Eightfold Way:** A method of classifying hadrons, by plotting hadrons with the same spin on a plot of strangeness against  $I_3$ .
- **Elastic Scattering:** A scattering event between two initial particles in which the final state consists only of the two initial particles.
- **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:**,  $\mathcal{Q}$ , for a non spherically-symmetric charge distribution  $\rho(\mathbf{r})$  is given by
 
$$\mathcal{Q} = \int (3z^2 - r^2)\rho(\mathbf{r})d^3\mathbf{r},$$
 where the  $z$ -axis is the axis of symmetry of the charge distribution.
- **Electroweak interactions** Weak and electromagnetic interactions.
- **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.

- **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).
- **fermi (fm):** Unit of length equal to  $10^{-15} m$ .
- **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
- **Fission:** The splitting of a heavy nucleus into two lighter nuclei, thereby releasing energy.
- **Flavour:** One of six species of quarks - u,d,c,s,t,b.
- **Flux:** The number of incident particles per second per unit area.
- **Fragmentation:** Process by which final state quarks and gluons are converted into hadrons.
- **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.
- **Gamma decay:** Radioactivity in which a nucleus in an excited state decays to a lower state emitting a high frequency photon.
- **Gauge boson:** Particle that acts as a carrier for a particular interaction.
- **Generation:** Synonymous with family.
- **Hadrons:** Strongly interacting particles.
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- **Half-life:** Time taken for a radioactive nuclide to decay to a quantity equal to one half of its original quantity.
- **Helicity:**  $\lambda$  The sign of the component of the spin,  $\mathbf{s}$  of a particle in the direction of its momentum  $\mathbf{p}$ .

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

- **Higgs field:** A field which has a non-zero constant value everywhere.
- **Higgs particle:** A particle which must exist if the Higgs field exists, owing to quantum fluctuations of the Higgs field.
- **Impact Parameter** of a projectile scattering off a target is the perpendicular distance of the initial velocity of the projectile from the target.

- **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).
- **Intrinsic parity:** The sign of the wavefunction of a particle under the parity operation (space reversal)
- **Islands of Isomers:** Regions of the Periodic Table where isomers are quite common.
- **Isomer:** A metastable excited state of a nucleus.
- **Isobar:** Nuclei with the same atomic mass number but different numbers of protons (neutrons).
- **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  $I$ .
- **Isotone:** Nuclei with the same number of neutrons but different numbers of protons.
- **Isotope:** Nuclei with the same atomic number but different atomic mass number.
- **Lepton:** A particle which does not participate in the strong (nuclear) interaction. A lepton may have electric charge.
- **Luminosity:** No. of particle collisions per unit area (usually quoted in  $\text{cm}^2$  per second).
- **Magic Numbers:** Nuclides with a magic number of protons or neutrons are particularly stable and tightly bound.
- **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  $c^2$ ).
- **Mean Lifetime:** Time taken for a radioactive nuclide to decay to a quantity equal to  $1/e$  times its original quantity.
- **Mesons:** Hadrons with integer spin (bosons).
- **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*.
- **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”).
- **Nuclear Magneton:** The magnetic moment of a proton with one unit of angular momentum, defined by

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

- **Nucleon:** A proton or neutron.
- **Nuclide:** A nucleus with a given atomic number and a given atomic mass number.
- **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.
- **Partial Width:** The width of a particle resonance in which the particle always decays into a particular channel.
- **Parton:** A quark, antiquark or gluon.
- **Parton Distribution Function:**,  $F_h^i(x)$ . The probability of finding a particular parton,  $i$ , inside a fact moving hadron,  $h$ , carrying a fraction  $x$  of the momentum of that hadron.
- **Pentaquark:** A particle consisting of four quarks and an anti-quark, whose flavour is different from that of any of the four quarks.
- **Propagator:** The quantum amplitude
- **Q-value:** The total energy released in a nuclear decay.
- **Quantum Chromodynamics (QCD):** Theory of strong interactions in which gluons interact with quarks changing their colour.
- **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.
- **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.
- **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.
- **Running coupling:** The effective coupling at different energy/momentum scales.
- **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.
- **Sea Quarks:** Clouds of quark-antiquark pairs that also exist within a hadron in addition to the valence quarks.
- **Semi-empirical Mass formula:** A formula for calculating the binding energy (and hence the mass) of a nucleus from the Liquid drop Model.

- **Strangeness:** The number of  $\bar{s}$  antiquarks in a particle minus the number of  $s$ -quarks.
- **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.
- **Vacuum Expectation Value:** The value of a field everywhere in space.
- **Valence Quarks:** The main quarks which are always inside a hadron and determine the hadron's properties.
- **Virtual Particles:** Particles that exist only for a short time and therefore can be off mass-shell
- **Weak Interactions:** Interactions between particles responsible for  $\beta$ -decay
- **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.
- **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.