

Nuclear Physics - Summary - Basic definitions

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This summary is based on the book Chapter 1 from Krane, Kenneth: Introductory Nuclear Physics, and the lecture slides NPP.1.1.

1 Basic definitions

Notation for nuclear species: A_ZX_N

where A is the atomic mass number,

Z is the atomic number (number of protons in the nucleus),

N is the number of neutrons in the nucleus.

Isotopes: chemical elements with the same number of Z (protons), but different number of neutrons (N and A are different). They have similar chemical properties to each other, but different physical properties. Examples: ${}^{12}\text{C}$, ${}^{14}\text{C}$, ${}^{235}\text{U}$, ${}^{238}\text{U}$.

Isotone: chemical elements with the same number of N (neutrons), but different number of protons (Z and A are different). Examples: ${}^2\text{H}$, ${}^3\text{He}$.

Isobar: chemical elements with the same A. They can have different Z and N. Examples: ${}^3\text{H}$, ${}^3\text{He}$; ${}^{40}\text{S}$, ${}^{40}\text{Cl}$, ${}^{40}\text{Ar}$.

Isotopologue: molecules that differ in isotopes. Example: ${}^{12}\text{CO}$, ${}^{18}\text{CO}$.

Atomic mass unit (u or a.m.u.): basic mass unit in nuclear physics. It is defined that so that the ${}^{12}\text{C}$ nucleus is exactly 12 u. This makes protons and neutrons approximately, but not exactly 1u in mass.

2 Particles and Forces:

Antiparticles: All charged particles have anti particles, whether the particle is an elementary particle or a hadron. The neutron has an anti particle, however neither the photon (γ) nor the neutral pion (π^0) has a distinct antiparticle. It is a convention to call the electron the particle and the positron its antiparticle.

Elementary Particles:

- **Fermions:** particles with half-integer spin.
 - **Leptons:** do not interact through the strong force. Have spin $\frac{1}{2}$. Examples: e^- , μ^- , τ^- , ν_e , ν_μ , ν_τ
 - **Quarks:** interact through the strong force. Have spin $\frac{1}{2}$. Examples: u, d, c, s, t, b
- **Bosons:** particles with integer spin. Examples: γ , gluons, W^+ , W^- , Z, Higgs boson

Composit Particles:

- **Hadrons:** bound state of quarks or antiquarks
 - **Baryons:** bound state of 3 quarks or antiquarks. Example: proton, neutron, antiproton
 - **Mesons:** bound state of an equal number of quarks and antiquarks. The most typical ones have one quark and an antiquark. Examples: π^0 , π^+ , π^-

Basic Forces:

- **electromagnetic:** acts between charged particles, the force carrier particle is the photon.
- **strong:** acts between quarks, the force carrier particles are the gluons.
- **weak:** acts between all fermions. The force carrier particles are: W^+ , W^- , Z bosons
- **gravity** (negligible for nuclear and particle physics): acts between all particles with mass