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: ${}^{A}_{Z}X_{N}$
where A is the atomic mass number,
Z is the atomic number (number of protons in the nucleaus),
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}C, ^{14}C, ^{235}U, ^{238}U.

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

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

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

Atomic mass unit (u or a.m.u.): basic mass unit in nuclear physics. It is defined that so that the ^{12}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 trough the strong force. Have spin $\frac{1}{2}$. Examples: e^-, μ^-, τ^-, ν_e, ν_μ, ν_τ
  - **Quarks**: interact trough 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:** bund 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