

Nuclear Physics

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1 Nuclear Structure

- The size of an atom is $1[\text{\AA}]$
- The size of the nucleus is $.001[\text{\AA}]$, or $1[\text{fm}]$
- The repulsive positive charges in the nucleus are held together by the strong nuclear force
 - Has a very short range
- Protons have a charge of e^+ and a spin of $\frac{1}{2}$, neutrons have no charge, but the same spin value
- Neutrons were discovered in 1932
- The atomic number is the sum of protons and neutrons
 - Thus, a nucleus with a mass number A contains Z protons and $N = A - Z$ neutrons
 - Neutrons and protons are referred to as nucleons
 - Nuclei with similar Z may have different N
 - For example, fully specifying a hydrogen atom, we may get:
 - * 1_1H_0
 - * 2_1H_1
 - * 3_1H_2
 - These are known as isotopes

2 Nuclear Size and Shape

- It is observed that the density of a nucleus does not depend on its atomic number A

$$\frac{N + Z}{\frac{4}{3}\pi R^2} \Rightarrow \frac{A}{R^2} \quad \text{is constant}$$

- The Nucleus Radius
 - We know $R = R_o A^{\frac{1}{3}}$
 - We also know $\rho = \frac{m}{V}$
 - Combining these, we get
- Nuclear Binding Energy

- $E_b = [Nm_n + Zm_p - m({}_Z^AZ_N)]$
- $\frac{E_b}{A} = \frac{\text{Binding energy}}{\# \text{ of nucleons}}$
- The binding energy to remove the least bound nucleon from the nucleus is on the order of [MeV], while the ionization energy of an electron is on the order of [eV]

- Stable and Unstable Nuclei

- Most nuclei are not stable
- They decay to lighter, more stable ones
- Decay Processes:
 - * α -decay — Emission of a helium nucleus, ${}_2^4He$