1(b). Size and Density

Majority of atomic nuclei have spherical shape and only very few show departure from spherical symmetry. For spherically symmetrical nuclei, nuclear radius is given by

$$R = R_0 A^{1/3}$$

where A is the mass number and $R_0 = (1.2 \pm 0.1) \times 10^{-15} m \approx 1.2\ fm$.

R varies slightly from one nucleus to another but is roughly constant for $A > 20$.

The radius of ${}^{12}_{6}\mathrm{C}$ nucleus is

$$R = (1.2)(12)^{1/3} \approx 2.7\ fm$$

Example: The radius of Ge nucleus is measured to be twice the radius of ${}^{9}_{4}\mathrm{Be}$. How many nucleons are there in Ge nucleus?

Solution: $R = R_o (A)^{1/3} \Rightarrow R_{Ge} = 2R_{Be} \Rightarrow R_o (A)^{1/3} = 2R_o (9)^{1/3} \Rightarrow A = 72$

Nuclear Density

Assuming spherical symmetry, volume of nucleus is given by

$$V = \frac{4}{3}\pi R^3 = \frac{4}{3}\pi R_0^3 A.$$

Mass of one proton = 1.67×10^{-27} kg, Nuclear Mass = $A \times 1.67 \times 10^{-27}$ kg.

$$\text{Nuclear density} = \frac{A \times 1.67 \times 10^{-27}}{\frac{4}{3}\pi R_0^3 \times A} \approx 10^{17}\,\mathrm{kg/m^3}$$

$$\text{Nuclear Particle Density} = \frac{\text{Nuclear Mass Density}}{\text{Nuclear Mass}} = \frac{10^{17}\ \mathrm{Kg/m^3}}{1.67 \times 10^{-27}\ \mathrm{Kg/Nucleon}}$$

$$= 10^{44}\ \mathrm{Nucleons/m^3}$$