Nuclear phenomenology

Nuclides

Nuclides are typically written as:

$$^{\mathrm{A}}_{\mathrm{Z}}\mathrm{Y}$$

where we note that:

A is the **mass/nucleon number** (# of nucleons)
Z is the **proton/atomic number** (# of protons)
N is the **neutron number** (# of neutrons)

with $\mathbf{A} = \mathbf{Z} + \mathbf{N}$. We also note that isotopes with: same A = isobars; same Z = isotopes; same N = isotones. Some elements have multiple isotopes, with different stabilty and abundance.

Nuclear shapes and sizes

Nuclei may be treated as static charge distributions with normalization:

$$\int f(\mathbf{r})\mathrm{d}^3\mathbf{r} = Ze$$

where e is the electron charge. Under the Born approximation, the cross-section $\frac{d\sigma}{d\Omega}$ is given by:

$$\left(\frac{d\sigma}{d\Omega}\right)_0 = \frac{Z^2\alpha^2(\hbar c)^2}{4\beta^4 E^2 \sin^4(\theta/2)}$$

including the electron spin, the Mott cross-section is given by:

$$\left(\frac{d\sigma}{d\Omega}\right)_{\mathrm{Mott}} = \left(\frac{d\sigma}{d\Omega}\right)_0 [1 - \beta^2 \sin^2(\theta/2)]$$

in the nonrelativistic limit with no spin dependence, the Rutherford cross-section is given by:

$$\left(\frac{d\sigma}{d\Omega}\right)_{\mathrm{Rutherford}} = \frac{(\hbar c)^2(\alpha Z)^2}{4m^2 v^4 \sin^4(\theta/2)}$$

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α emissions