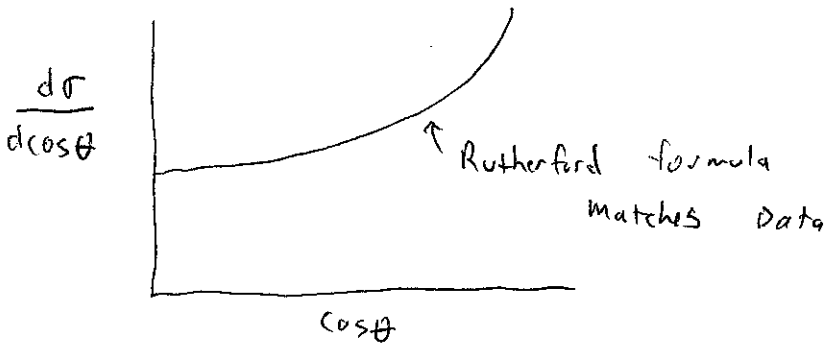
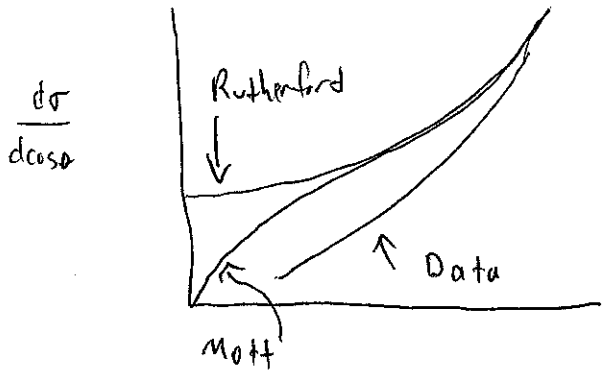
The Nucleus

~ 10 MeV α- particles

Can't get close enough to nucleus to probe its size



~100 MeV electrons can interact with nucleus



$$\left(\frac{d\sigma}{d\cos\theta}\right)_M = \left(\frac{d\sigma}{d\cos\theta}\right)_R \overbrace{2\left[1 + \frac{(1+\cos\theta)E_K}{Mc^2}\right]}^{1+\cos\theta}$$

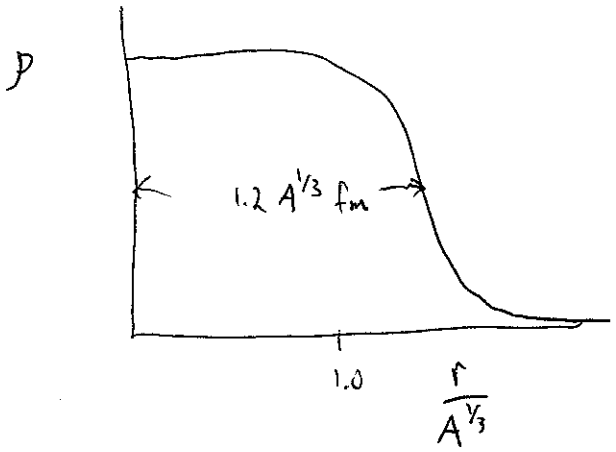
Corrections from 'spin' and nuclear re-coil

M ↑ Mott

R ↑ Rutherford

Nucleus is not pointlike

charge Distribution in the nucleus



Chapter II

A - nucleon mass

Z - nuclear charge

Observation $A > Z$ except a for single proton

Can nucleus be made up of A protons

and A-Z electrons?

An electron trapped in the nucleus has a

minimum wavelength $\lambda \sim 5$ fm

$$E_K = \sqrt{(pc)^2 + (Mc^2)^2} - Mc^2$$

$$pc = \frac{hc}{\lambda} \simeq 250 \text{ MeV}$$

$E_K \sim 250$ MeV beta decay $E_K \sim 10$ MeV

Coulomb energy

$$V = \frac{Ze^2k}{r} \approx 23 \text{ MeV}$$

Nucleus isn't made up of protons and electrons

new evidence

$$\alpha + {}^9\text{Be} \rightarrow (\text{new nucleus}) + Y$$

Y: unknown neutral particle

$Y + p \rightarrow Y + p$ protons have $E_K = 5.7$ MeV after scattering

is Y a photon?

Scattering results don't agree with Compton scattering

^{11}B and ^{14}N masses well known

$$\alpha + {}^{11}B \rightarrow {}^{14}N + n$$

$$\frac{1}{2} m_\alpha v_\alpha^2 + m_\alpha c^2 + m_B c^2 = \frac{1}{2} m_N v_N^2 + m_N c^2 + \frac{1}{2} m_n v_n^2 + m_n c^2$$

$$m_\alpha \vec{v} = m_n \vec{v}_n + m_N \vec{v}_N$$

using $m_n \ll m_N$

$$\frac{1}{2} m_n v_n^2 + m_n c^2 = \frac{1}{2} m_\alpha v_\alpha^2 + m_\alpha c^2 + m_B c^2 - m_N c^2$$

$m_n c^2 = 938 \text{ MeV}$ - Chadwick

Actual $m_n c^2 = 939.57 \text{ MeV}$

$m_n c^2 > m_p c^2$

$m_n c^2 - m_p c^2 = 1.29 \text{ MeV}$

---

protons and neutrons have

$S = \frac{1}{2}$

attractive interaction due to 'strong Force'

range $\sim$ 1 fm

The sum of the masses of individual protons and neutrons is greater than the mass of a nucleus

α particle

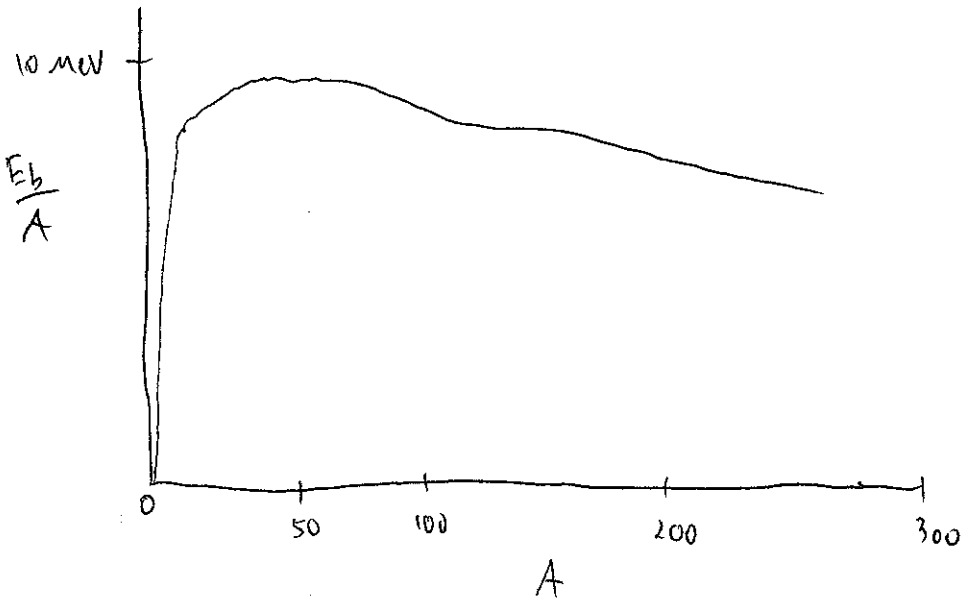
$m_\alpha = 3727.41 \text{ MeV}/c^2$

$m_p = 938.27 \text{ MeV}/c^2$

$m_n = 939.57 \text{ MeV}/c^2$

$E_b = 2m_p c^2 + 2m_n c^2 - m_\alpha c^2 \approx 28.3 \text{ MeV}$

$\frac{E_b}{A} \approx 7.1 \text{ MeV}$



Liquid Drop Model

$$E_b^{\text{even-odd}} \approx C_1 A - C_2 A^{2/3} - \frac{C_3 Z^2}{A^{1/3}} - \frac{C_4 (A-2Z)^2}{A}$$

- $C_1 A$: strong force, all nucleons feel all others
- $C_2 A^{2/3}$: nucleons on the surface have less neighbors
- $\frac{C_3 Z^2}{A^{1/3}}$: Coulomb repulsion
- $\frac{C_4 (A-2Z)^2}{A}$: Pauli Exclusion

\+ pair energy term

for $(A-Z)$ - odd Z - even
or $(A-Z)$ - even Z - odd $\quad E_b^{\text{even-odd}}$ is unmodified

$(A-Z)$ - even Z - even

$$E_b^{\text{even-even}} = E_b^{\text{even-odd}} + \frac{11.18\ \text{MeV}}{\sqrt{A}}$$

$(A-Z)$ - odd Z - odd

$$E_b^{\text{odd-odd}} = E_b^{\text{even-odd}} - \frac{11.18\ \text{MeV}}{\sqrt{A}}$$

this is the 'weizsaecker formula' or 'semiepercal mass formula'