Wesley Lacaze

~~[illegible]~~ Modern Physics 4 Nov 14

Ze $e = 1.6 \times 10^{-19}$ C

↑

nucleus charge

a) 99.98% mass in nucleus

b) radius ~ a few times 10^{-15} m = 1fm

~ 10^{-14} volume of an Atom

Mass

a) Atoms with same Z but diff. mass → isotopes

$\rightarrow Q = \underset{\sim}{Z} \cdot e$ $A = Z + \underset{\sim}{N}$

# of protons # of neutrons

$^{11}_{5}B$ ← AZ ← AZ

proton: $Q = +e$, $m_p c^2 = 938,272 \ldots \text{eV}$
$= 938.27 \text{MeV}$

neutron: $Q = \emptyset$, $M_n = 939.56 \text{MeV}$

$$M_A = Z \cdot m_p + N m_n \ (+ Z m_e)$$

Atom proton neutron electron

adding c^2 and BE

$$M_A = Z \cdot M_p c^2 + N m_n c^2 (+ Z M_e c^2) - BE$$

Binding Energy is negative because forces are attracted

Nuclear Binding Energy = 7-8 MeV · A

Nuclear Force very strong because protons and neutrons are very close together and have high velocity (20%-30% c) so large amount of energy needed to "Bind" together

proton
neutron } nucleons

More nucleons, more "neighbors" so more BE

$\approx$ 7-8 MeV · A

(refer to Nuclear Binding energies graph online)

Yet as nucleus becomes larger (+)energy of repulsive protons overcome BE(-) so energy starts a more (+) trend

If atom splits electrostatic repulsive energy is liberated

thus gain MeV $\rightarrow$ fission, e.g

$^{236}_{92}U \rightarrow {}^{100}_{42}Mb + {}^{127}_{50}Sn + 8n + 146\ MeV$

$\approx 0.5\ MeV/N$

$^{2}H + {}^{3}H \xrightarrow[\text{fuse}]{} {}^{4}_{2}He$ + Neutron $+ 17.6\ MeV$

huge gain of energy

$\approx 3.5\ MeV/N$

$A = Z + N$

Mass #

M_A / u

"true" mass seen on Periodic table

$u = \frac{1}{2}$ mass(^{12}C)

$u = 931.4\ \frac{MeV}{c^2}$

proton has $S = \frac{1}{2}$
neutral has $S = \frac{1}{2}$ > thus fermions and follow exclusion principle

Stable nuclei tend to have more neutrons than protons (less electrostatic repulsion)

(refer to graph online "Stable nuclei")

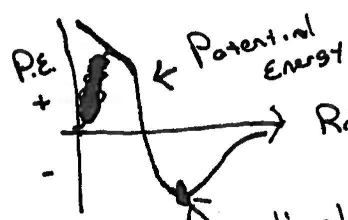
Size

$$\text{Radius of nucleus } (R_A) \simeq \underset{\uparrow \text{ constant}}{R_b} \cdot \sqrt[3]{A}$$

Volume $\frac{4\pi}{3}R^3$ directly porportional to A

nucleons don't want to "squeeze" together or "seperate"

mutual attraction between nucleons called <u>Strong Force</u>



Radius ⟵ Shows distance between nucleons

optimal position for nucleons

high PE when nucleons are real close

BE only dependent on near "neighbors"

stable nucleus w/ neutrons

$A=1$ .... $A \simeq 300$ ..... 10^{57}

↑ neutron star

(gravity helps w/ very neutral force to bind together)