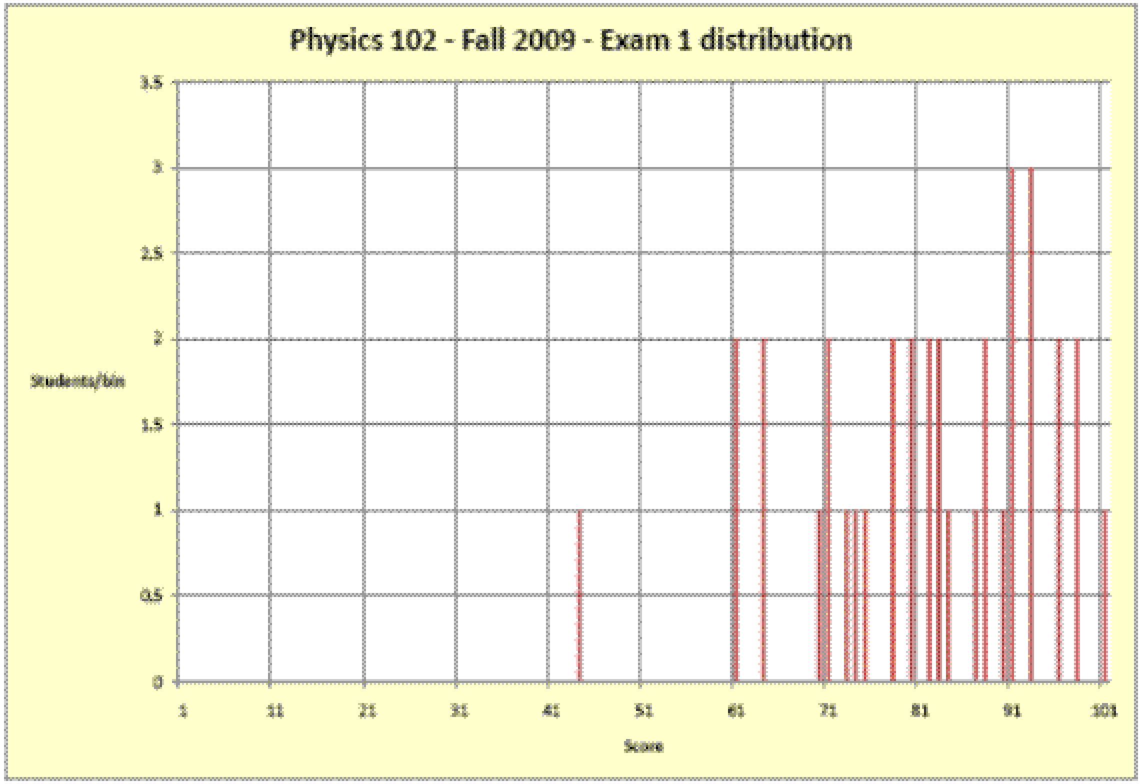
Physics 102 - October 21, 2009

- Exam 1 graded - Available at end of class today... here
  - Will be in box outside my office Door After that

mean Score ~ 80
Median Score ~ 81

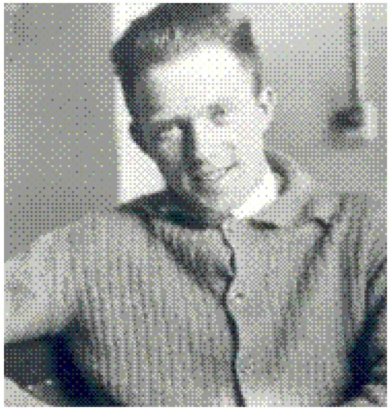


- Solns and distribution posted on web

Last Time

$$\Delta x \Delta p \geq \frac{h}{2\pi}$$

$$\Delta E \Delta t \geq \frac{h}{2\pi}$$

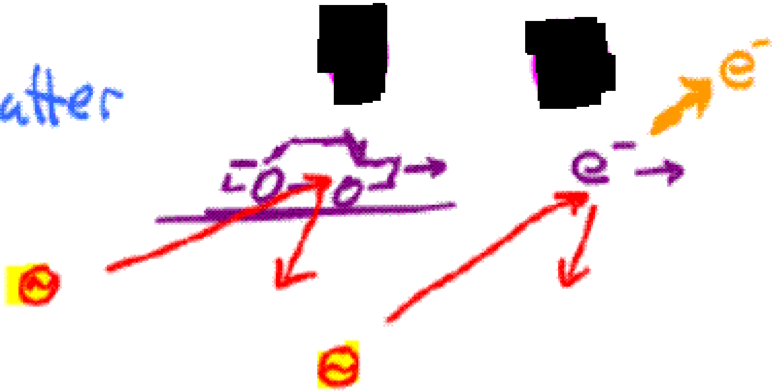


Heisenberg's uncertainty Principle

~1927

Say goodbye to the deterministic universe

Size Really DOES matter



Say goodbye to the deterministic universe

"apparent" loophole in energy conservation holds the key to understand Forces and much of cosmology

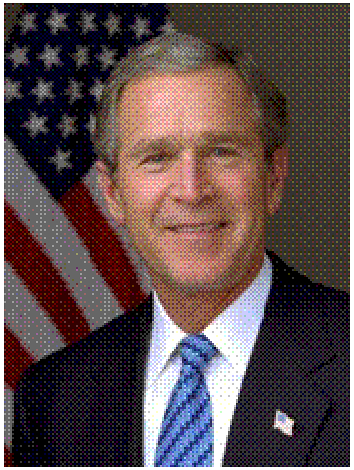
Say hello to the Harry Potter Universe

Quantum Field Theory → Exchange force

We'll come back To this ...

The Journey into Inner Space

Nuclear physics



By the way, the word ‘nuclear’ is pronounced

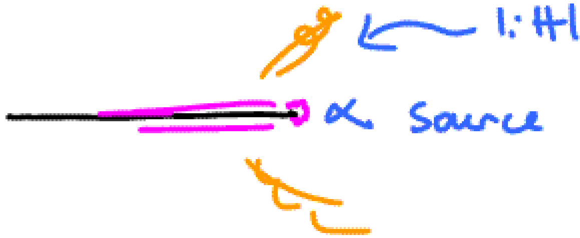
nūk-lē-ər

and *<u>not</u>*

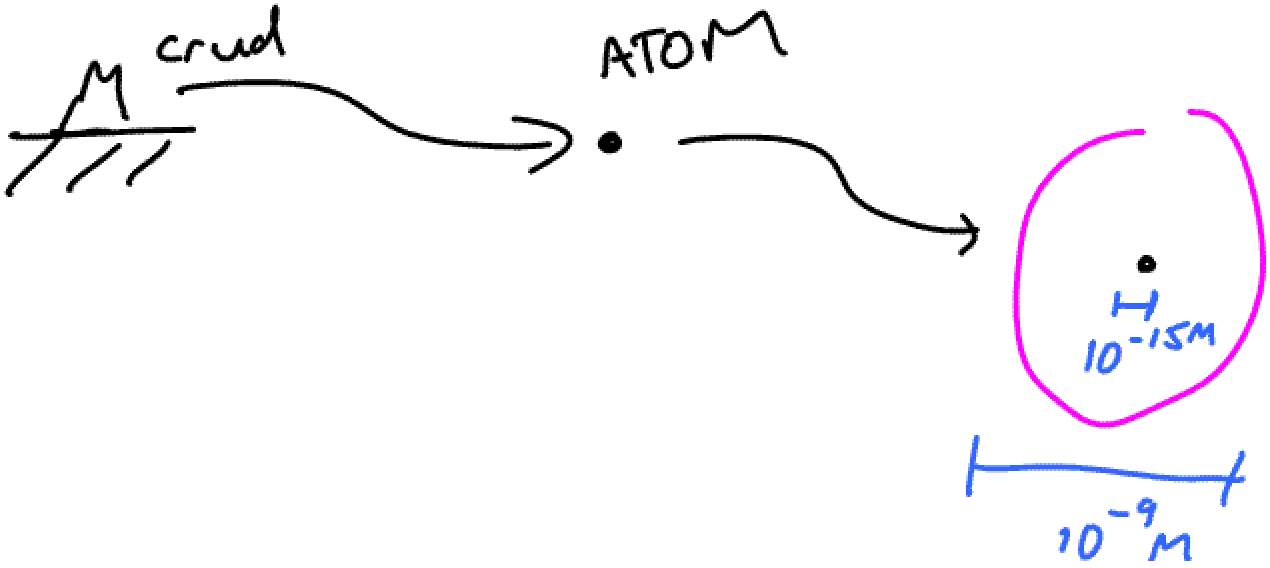
nūk-ū-lər.

Got that Mr. President!?

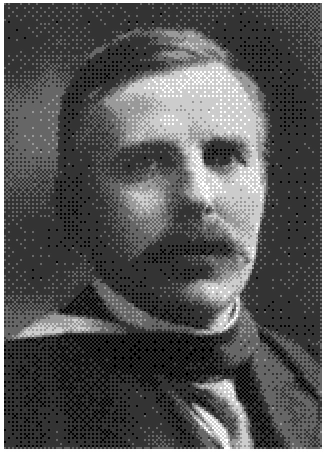
Cloud chamber



little streaky wisps where α particle passes and condenses mist



The nuclear Model of the atom

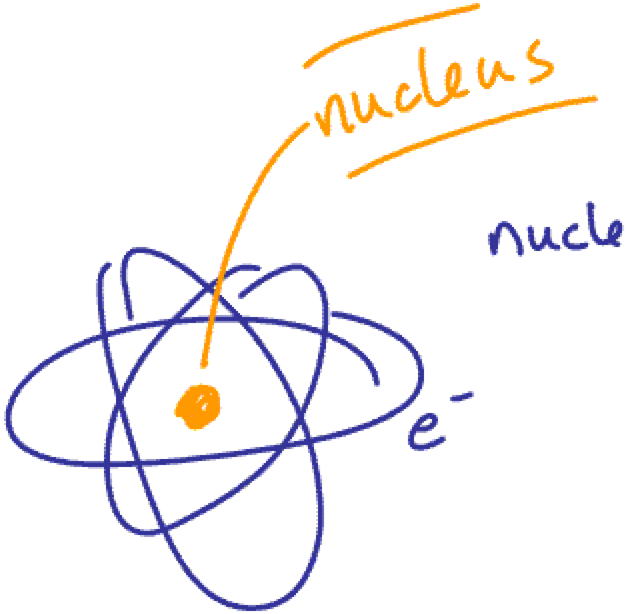


Ernest Rutherford

(1871 - 1937)

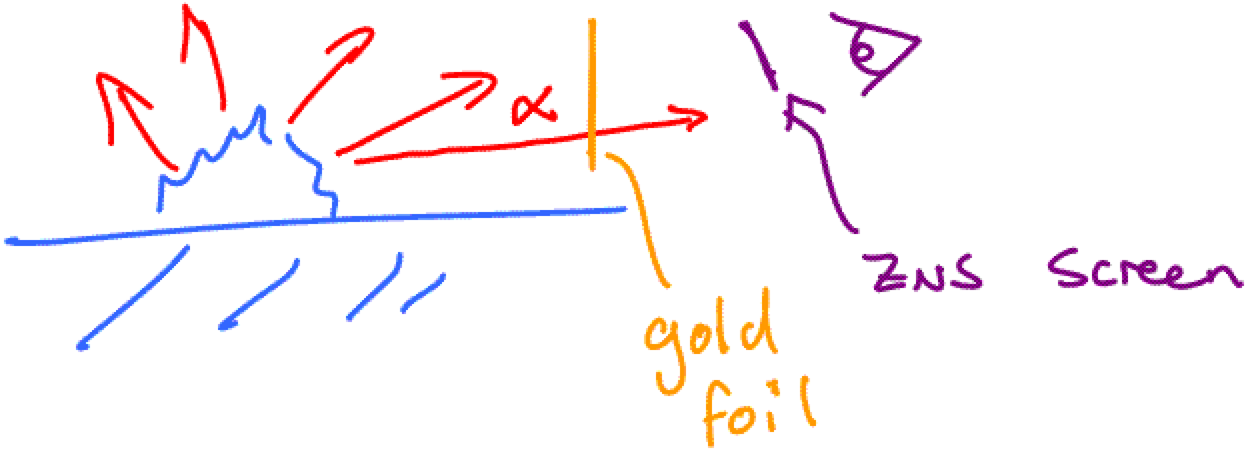
New Zealand Farm boy

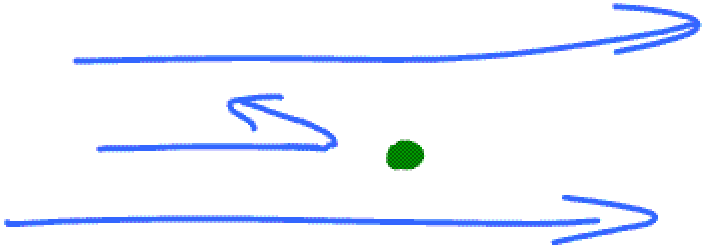
→ Manchester, England



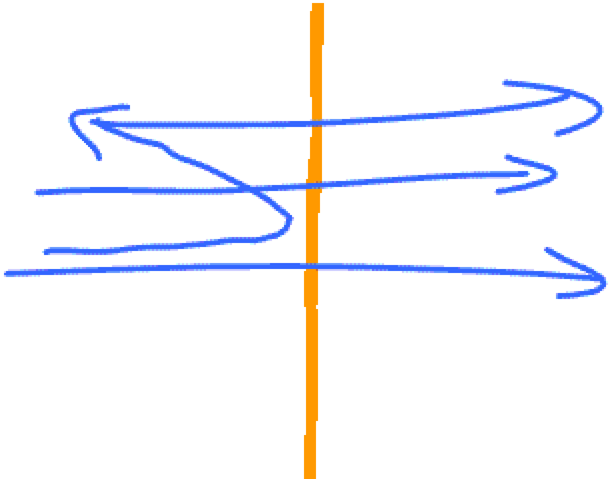
nuclear

Plum Pudding

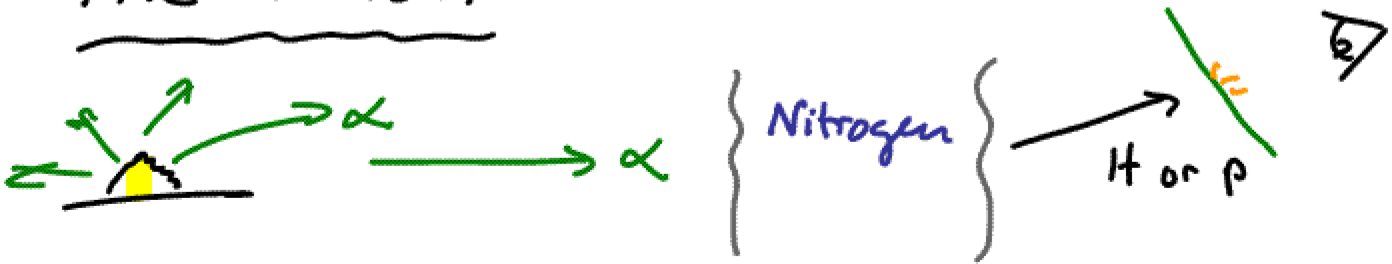




The dramatic "hard" scatters prove that positive charge compressed in small nucleus



The Proton



Rutherford 1918

Mass ~ 938 MeV/c^2

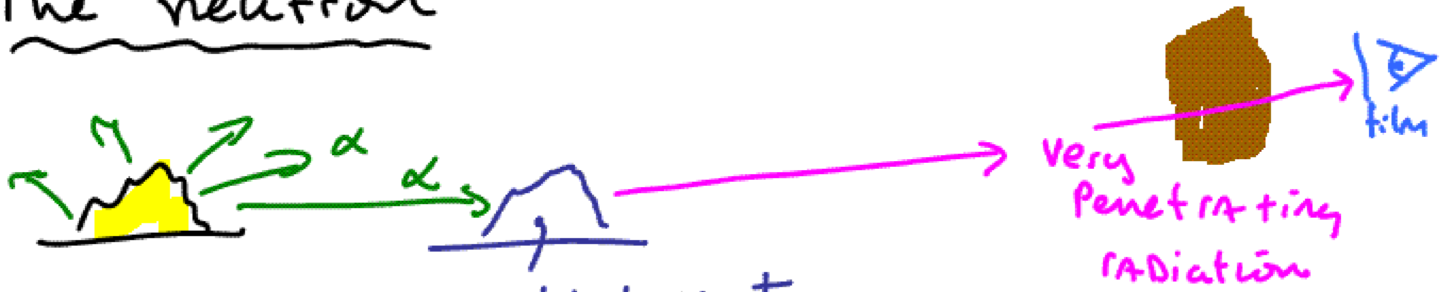
Protons $q = +1\,|e|$

Fermion spin $\frac{1}{2}$

for comparison

$M_{e^-} \sim 0.511\ \text{MeV}/c^2$

The neutron



1930 walther Bothe

H. Becker
(Germany)

1954 Nobel Prize in Physics
"For the coincidence method and his discoveries made therewith"

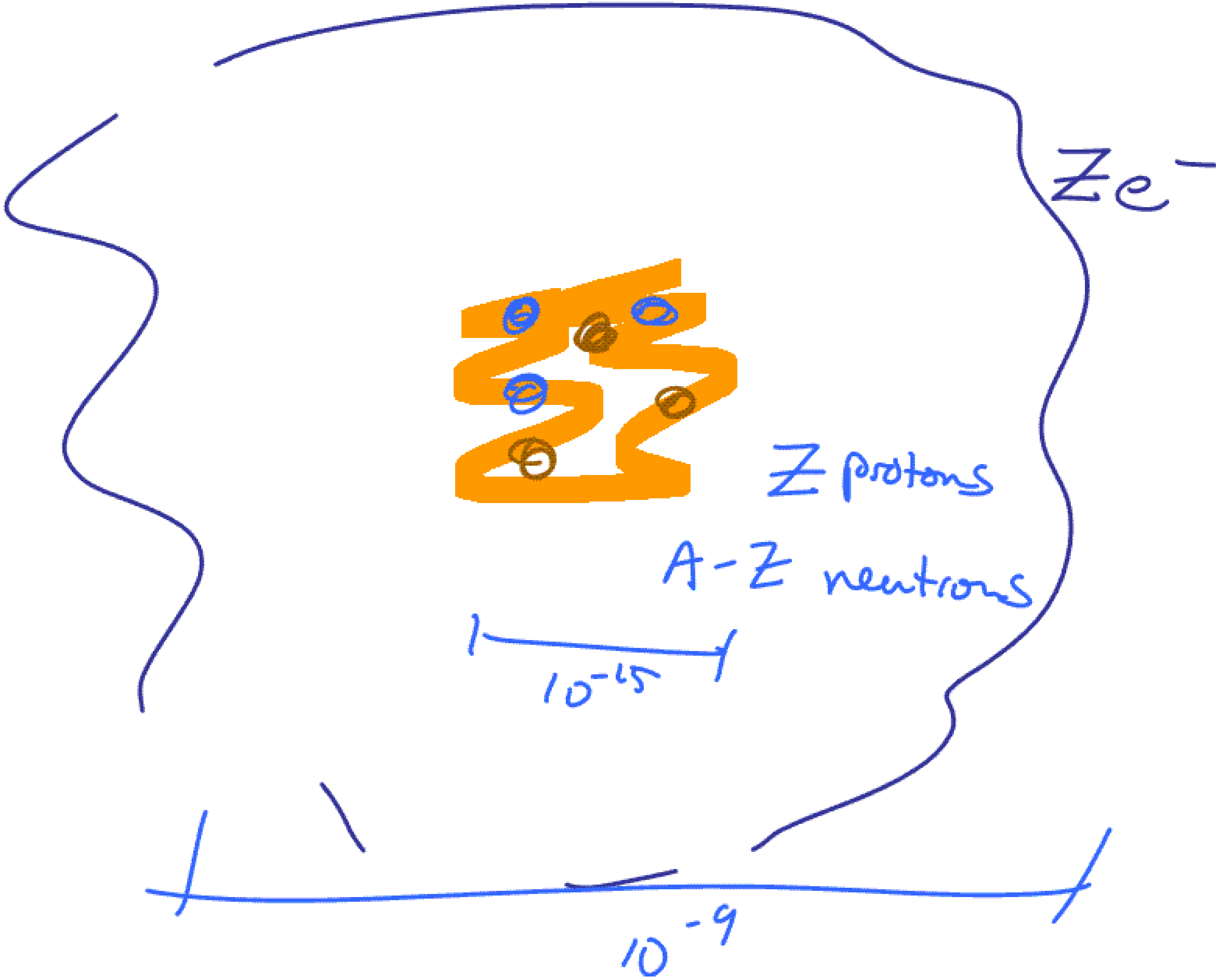
1932 James Chadwick → 1935 Nobel Prize "For discovery of the neutron"
(England)

Showed this penetrating radiation to NOT be γ-rays

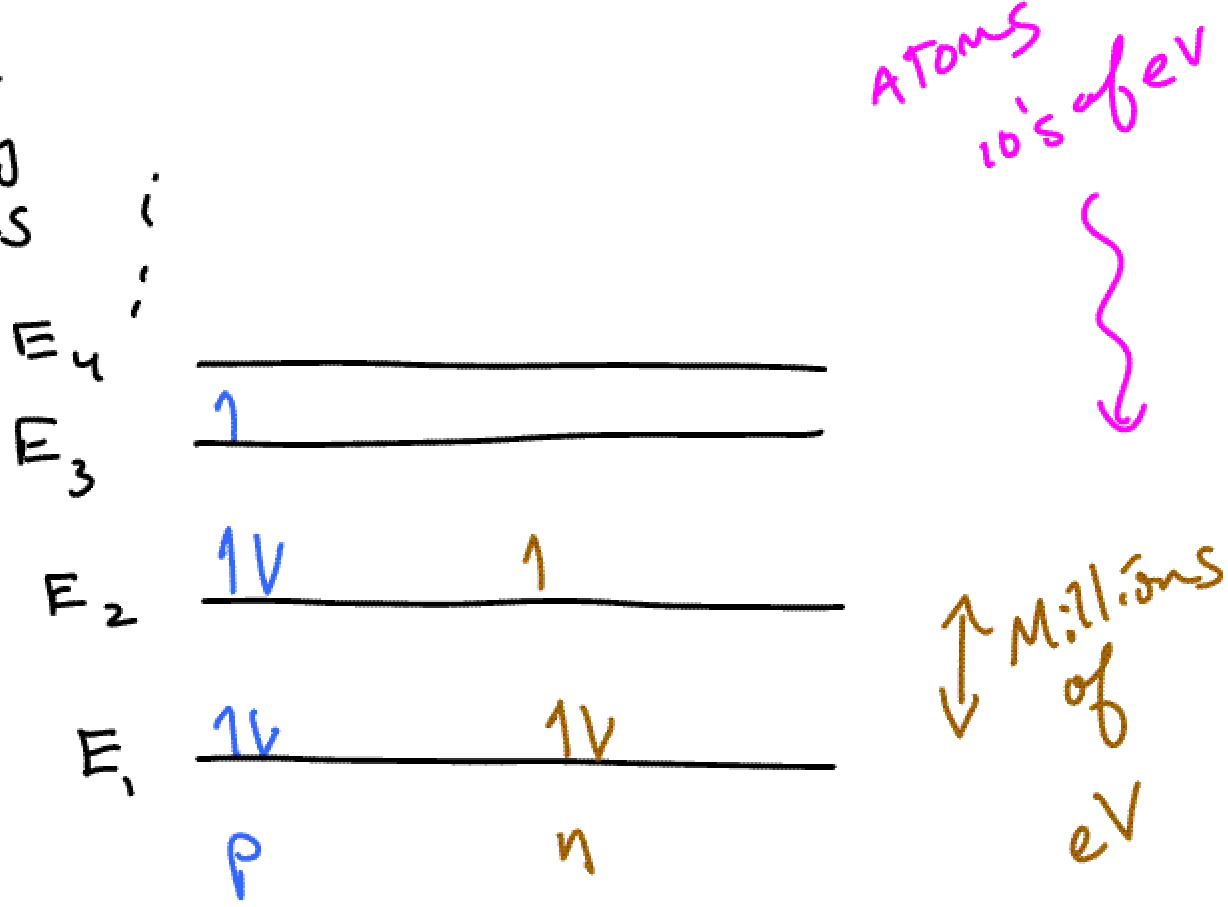
Showed had mass similar to proton and was unchanged

Mass of neutron ~ 940 MeV/c^2

electric chg = 0
Spin = 1/2 fermion


Ze⁻
Z protons
A-Z neutrons
10^-15
10^-9

Discrete energy levels



In a fashion similar to the electron energy levels in an atom — neutrons and protons occupy discrete energy levels in a nucleus. Typical energy differences between levels is Millions of electron-volts (as opposed to tens of electron-volts for atomic levels).

$$\boxed{{}^{A}_{Z}X}$$

X, Z same info

Symbol for a nucleus

$X \equiv$ Atomic Symbol

$Z \equiv$ # protons — Atomic #

$A \equiv$ Atomic Mass

$N \equiv A - Z \equiv$ # neutrons

$${}^{A}_{Z}X^{*} \longrightarrow {}^{A}_{Z}X + \gamma$$

GAMMA radiation

γ

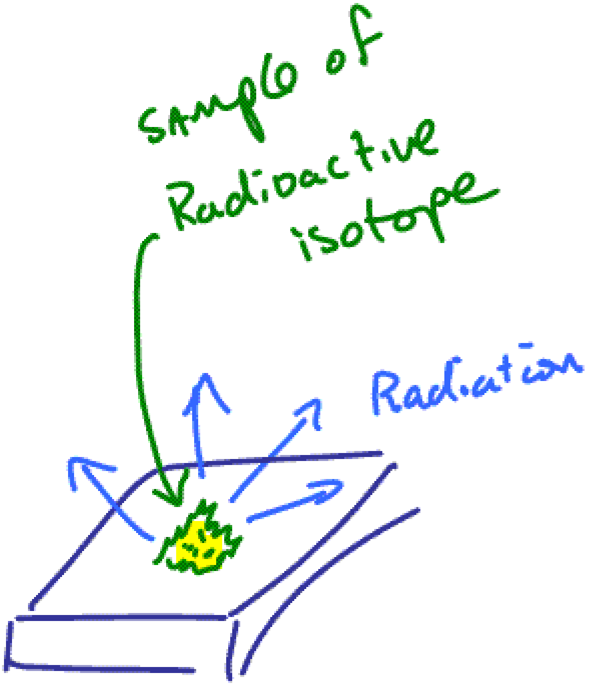
$$\left.\begin{array}{l} {}^{A}_{Z}X' \longrightarrow {}^{A}_{Z+1}X + e^{-} \\ \\ {}^{A}_{Z}X' \longrightarrow {}^{A}_{Z-1}X + e^{+} \end{array}\right\} \beta$$

β radiation

$${}^{A}_{Z}X' \longrightarrow {}^{A-4}_{Z-2}X + \alpha$$

Alpha radiation

$${}^{4}_{z}He$$



decay constant

$$\frac{\Delta N}{\Delta t} = \lambda N$$

N = # radioactive nuclei in sample

Activity ≡ # nuclei decaying per second

$$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$$ ≡ half-life ≡ time for ½ the nuclei to decay

$\left.\begin{matrix} t_{1/2} \\ \lambda \end{matrix}\right\} \equiv$ both characterize how prone a specific type of nucleu is to break down (decay)

large λ, small $t_{1/2}$ means nuclei prone to decay quickly

Small λ, large $t_{1/2}$ nuclei tend to stick around longer

λ and $t_{1/2}$ ... measures of the same characteristic

Sort of like a fingerprint for specific type of radioactive nucleus

N atoms in sample at time = 0

$$\text{Activity} \equiv \frac{\#\text{decays}}{\text{second}} = \frac{\Delta N}{\Delta t} = \lambda N$$

decay CONSTANT

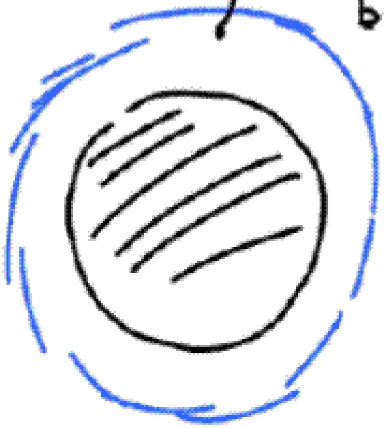
halflife ≡ $t_{1/2}$ = time for ½ sample to decay

$$t_{1/2} = \frac{0.693}{\lambda}$$

Radioactive Dating

"Normal" carbon $^{12}_{6}C$

$^{14}_{6}C$ Produced by cosmic rays Hitting Atmosphere



^{14}C is naturally radioactive β-emitter $t_{1/2}$ = 5730 years

- ^{14}C incorporated into living tissue
- Stops at death
- $^{14}C/^{12}C$ ratio gives estimate of time since death
- ^{14}C concentration in Atmosphere varies, calibrate w/ tree rings