

Physics 100 - March 18, 2009

■ Exam 1 - can pick up

■ Presentation Preference sheets

- ordered list of 5 most preferred topics
1 - most preferable

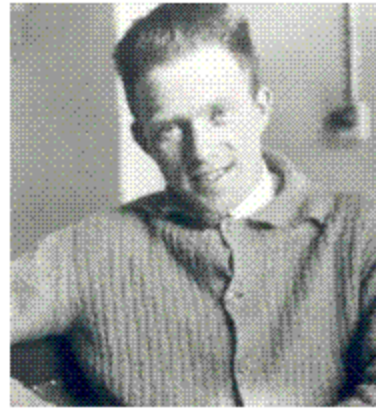
- Put Name of individuals you'd like to
work with ... I'll try to accomodate

- To me by end of Thursday.
(Now if you can)

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

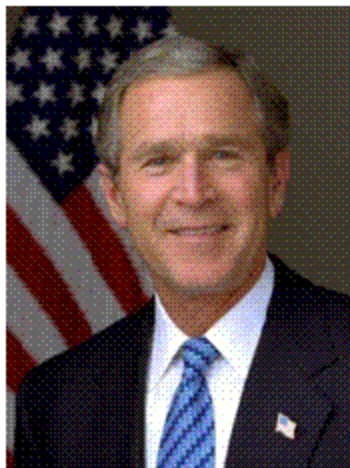
gives us an "apparent" loophole in
energy conservation that holds the
key to understanding forces and
much of cosmology.

Say hello to the Harry Potter Universe
We'll come back to this . . .



The Journey into Inner Space

Nuclear physics



By the way, the word
'nuclear' is pronounced

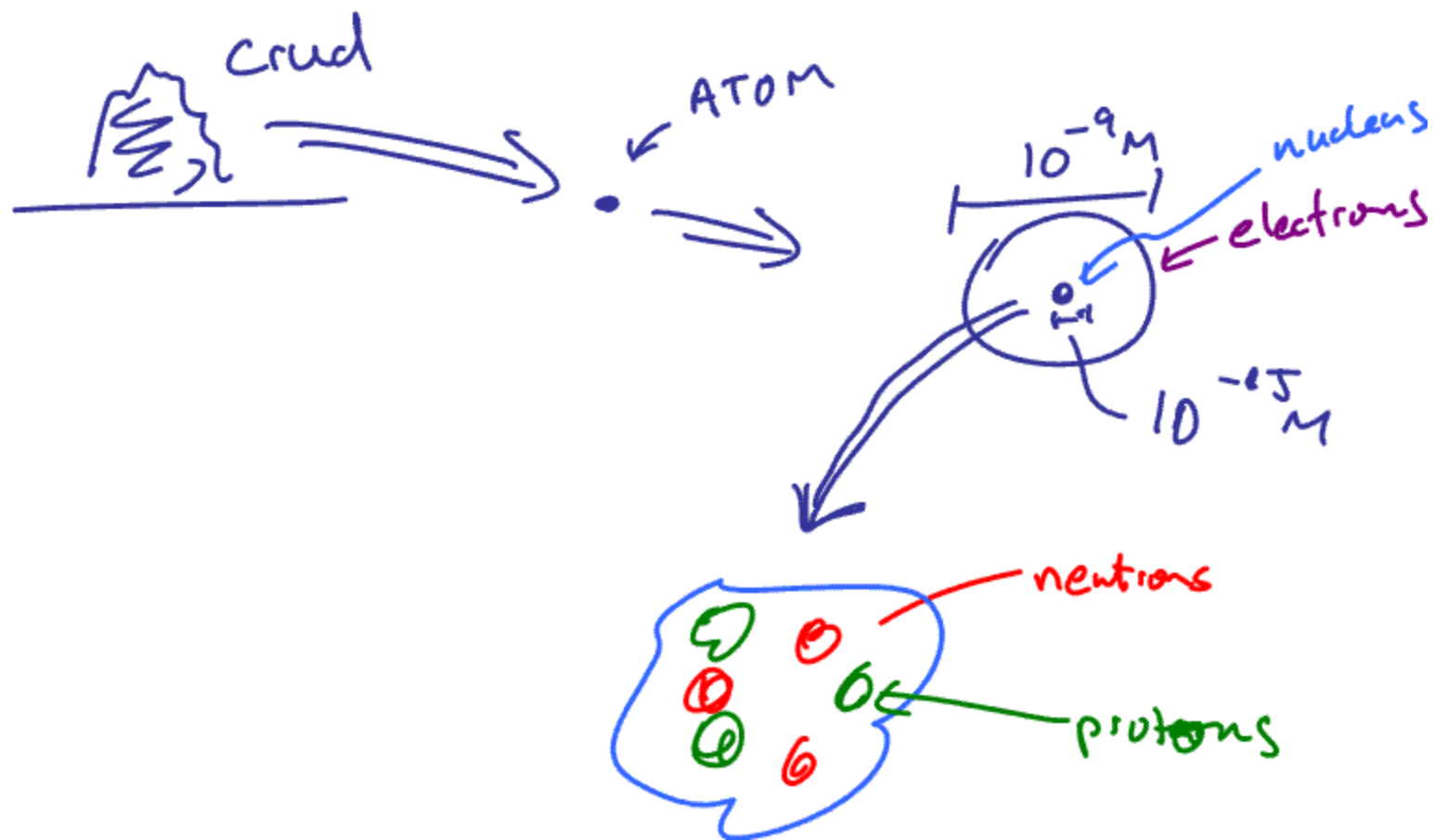
nūk-lē-ər

and not

nūk-ū-lər.

Got that Mr.
President!?





The nuclear Model of the atom

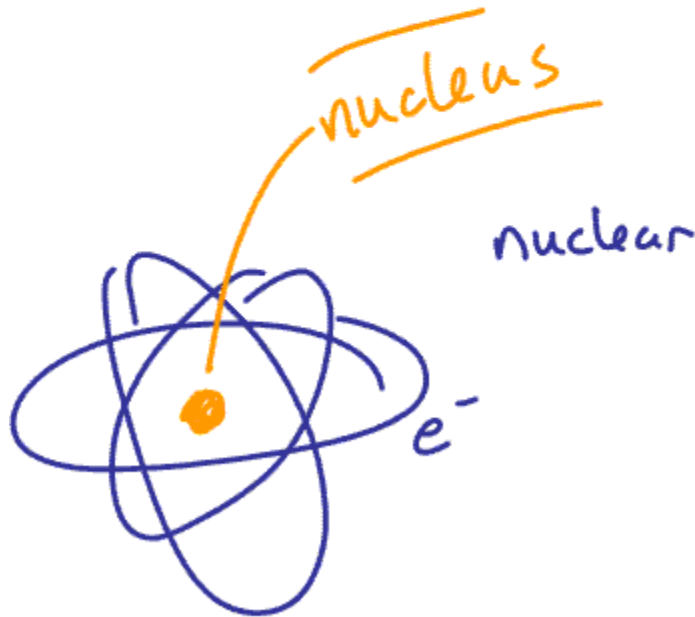
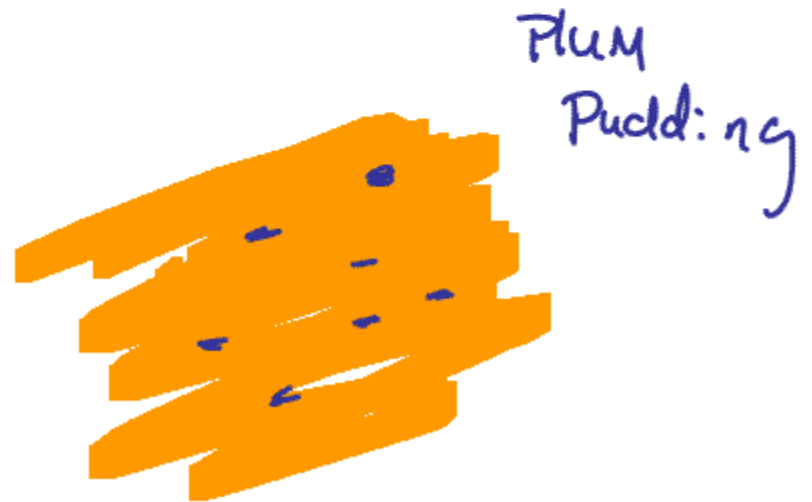


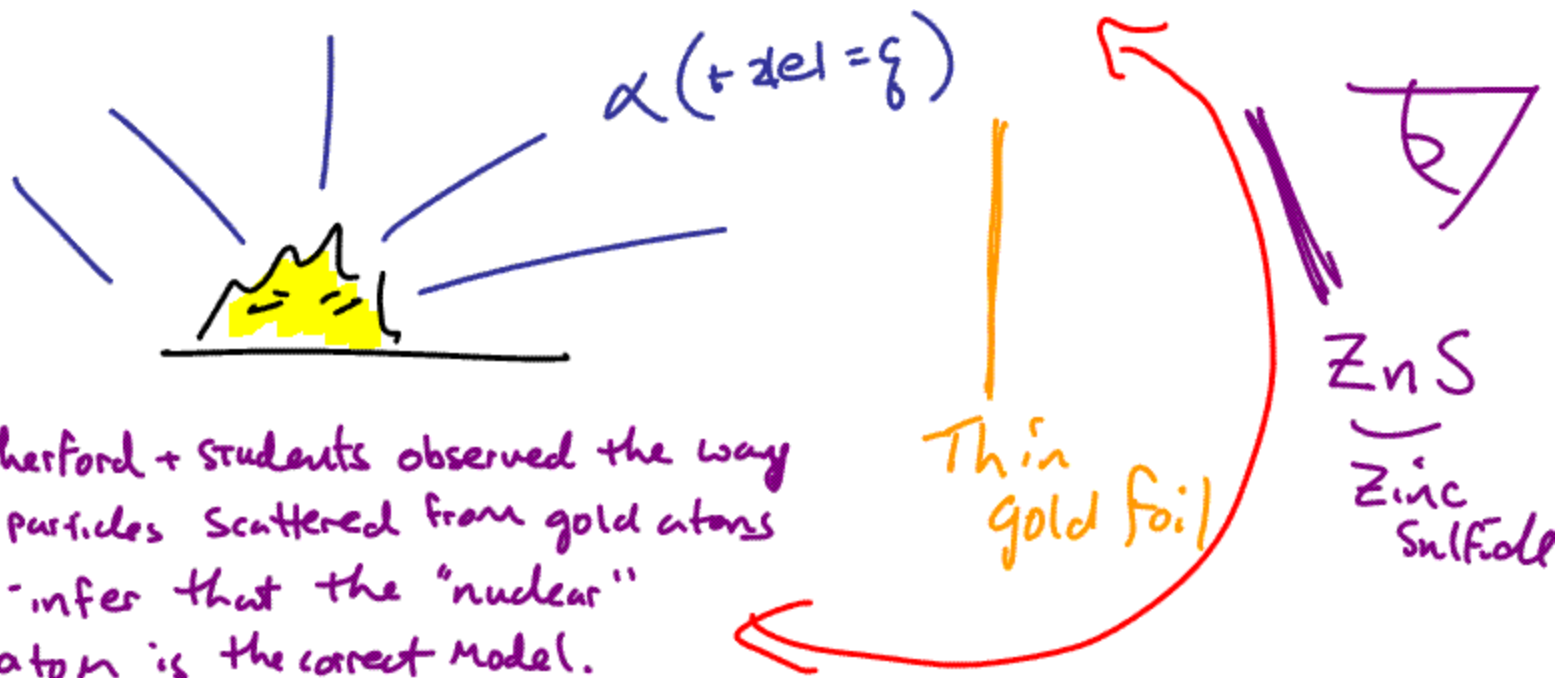
Ernest Rutherford

(1871 - 1937)

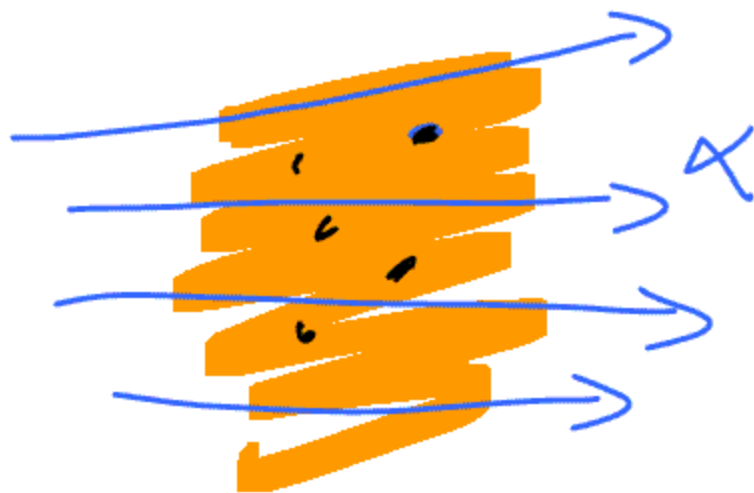
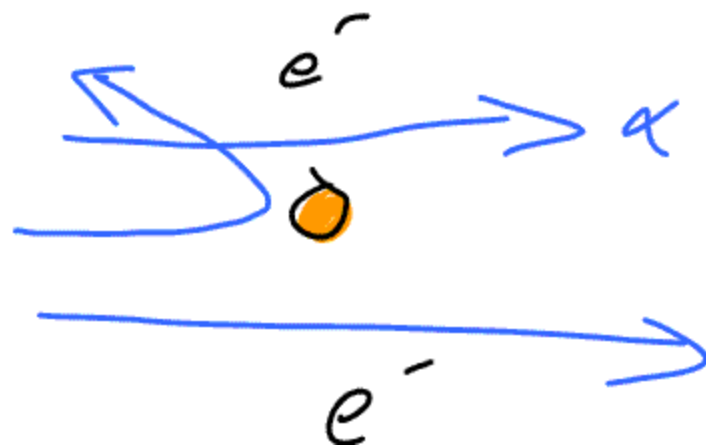
New Zealand Farm boy

↳ Manchester, England

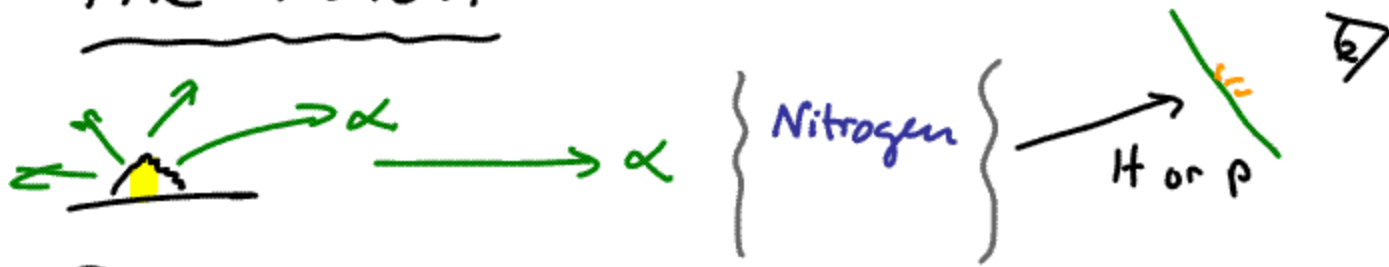




Rutherford + students observed the way
 α -particles scattered from gold atoms
 to infer that the "nuclear"
 atom is the correct model.



The Proton



Rutherford 1918

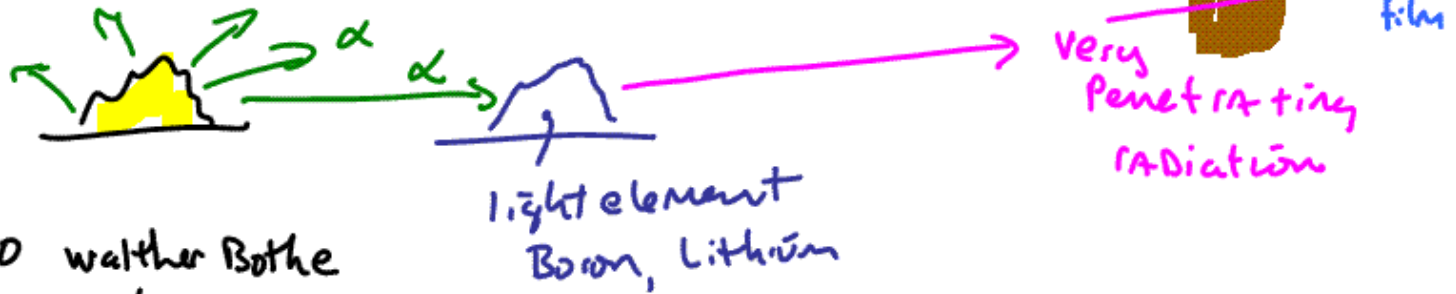


Mass $\sim 938 \text{ MeV}/c^2 = 1 \text{ AMU} \sim \text{Atomic Mass Unit}$
Charge = $+1$

for comparison Mass of electron $\sim 0.511 \text{ MeV}/c^2$

Spin = $\frac{1}{2} \rightarrow \text{Fermion}$

The neutron



1930 Walther Bothe

↙ H. Becker
(Germany)



1954 Nobel Prize in Physics

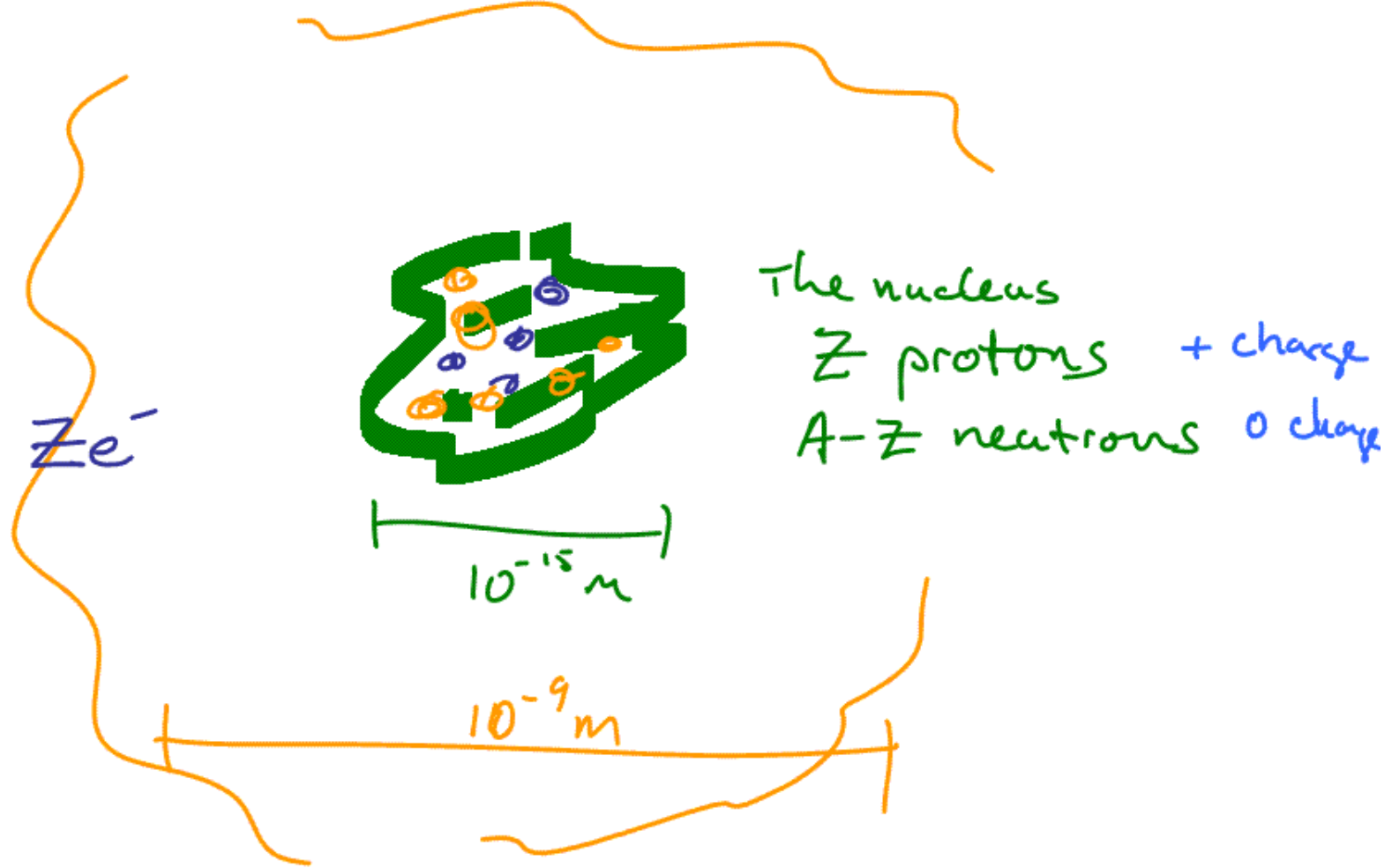
"For the coincidence method and his discoveries made therewith"

1932 James Chadwick
(England)



→ 1935 Nobel Prize "For discovery of the neutron"
Showed this penetrating radiation to NOT be γ -rays
Showed had mass similar to proton and was uncharged

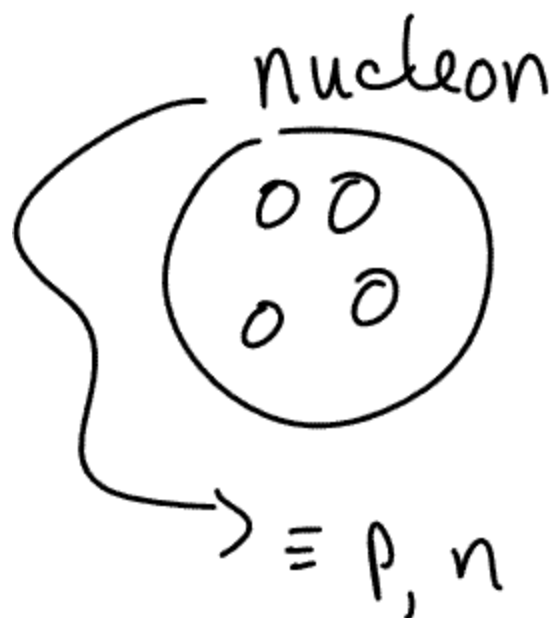
Mass of neutron $\sim 940 \text{ MeV}/c^2$ electric chg = 0
Spin = $1/2$ fermion



Hypothesize $\rightarrow$ The Strong nuclear force

$p \rightarrow \quad \leftarrow p$
coulomb repulsion to 10^{-15} m

at 10^{-15} m new Attractive force

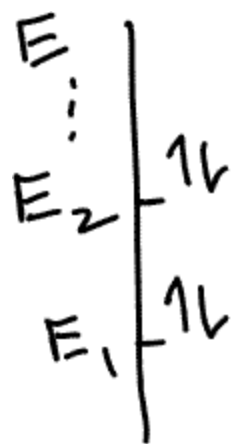


Schrödinger's eqn

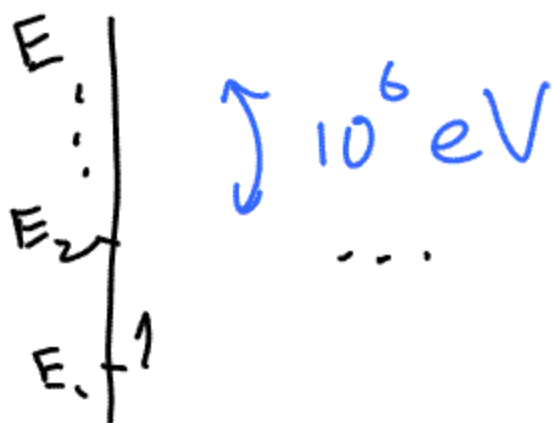
discrete energy levels

n, p both fermion

Populate energy levels
separately



Protons



Neutrons

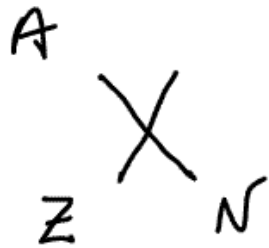


ATOM

discrete energy levels in nuclei separated in energy by millions of eV ...

Whereas the energy levels for electrons in the atom are separated by $\sim 10\text{eV}$

How to represent a nucleus



$X \equiv$ Atomic Symbol

$Z \equiv$ # protons Atomic #

$A \equiv$ Atomic Mass

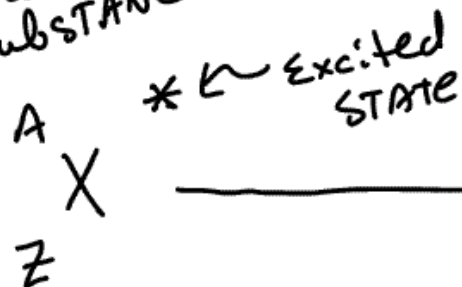
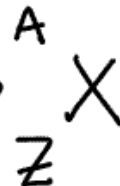
$N \equiv A - Z \equiv$ # neutrons

chemistry determined by Z

can have atom w/ same Z , different A
different # neutrons

Naturally
Radioactive
Substance

Isotope



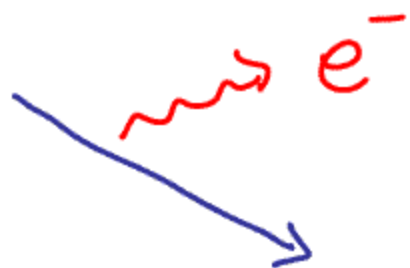
photon

gamma ray

very
penetrating

$$E = mc^2$$

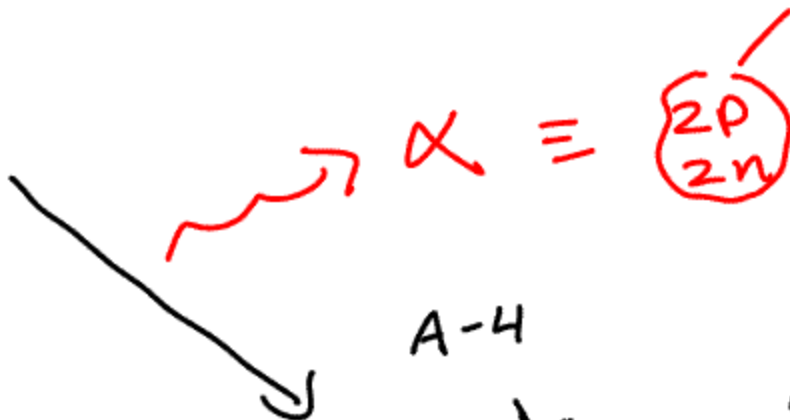
A
 X'
 Z



A
 X
 $Z+1$

(β ray)
 β -radiation

A
 X'
 Z



$A-4$
 X
 $Z-2$

He nucleus

Heavily "ionizing"
NOT penetrating

α -radiation

Different nuclear isotopes

↳ different nuclear
Shell Structure
(energy levels)

Naturally radioactives

↳ characteristic decay time

half life $\equiv t_{1/2} \equiv$ time it takes for
 $\frac{1}{2}$ nuclei in a sample
to decay



$$\frac{\Delta N}{\Delta t} \sim N$$

← # decays

time Δt
Amount of time

↑
of nuclei

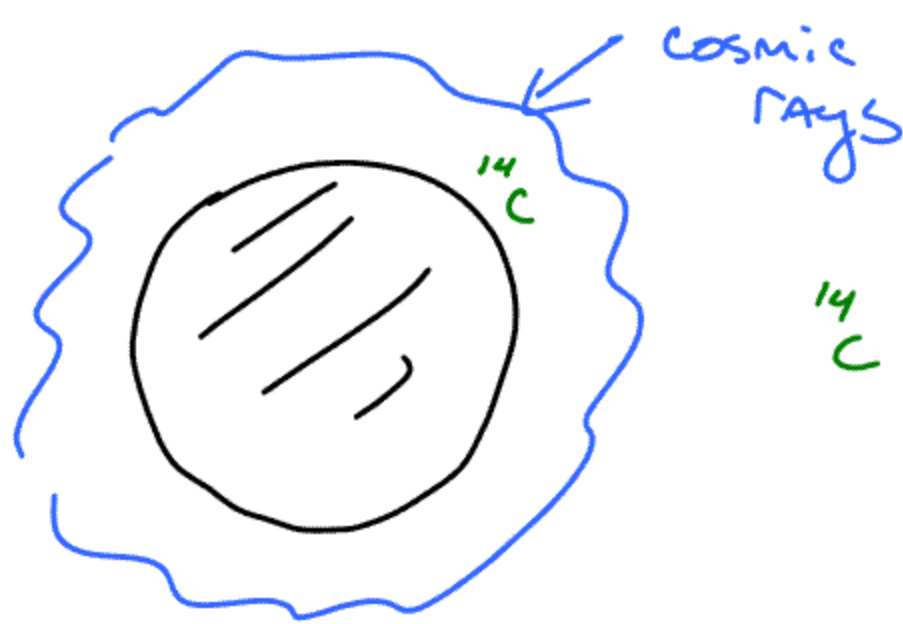
$$\text{Activity} = \frac{\Delta N}{\Delta t} = \lambda N$$

(decays/second)

↑
decay
constant

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

relation between decay constant λ
and half life $t_{1/2}$



Carbon dating

^{14}C β emitter

$t_{1/2} = 5730 \text{ years}$

^{14}C continually made in atmosphere.

^{12}C NOT radioactive, ^{14}C is radioactive ($t_{1/2} = 5730 \text{ yrs}$)

When living thing dies, it stops incorporating ^{14}C in its tissue. ^{14}C decays away. So, amount of ^{14}C in organic material can be used for accurate "dating" of time of death for historical organic objects